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Unesco sourcebook for out-of-school science and technology education

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science and technology education

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Preface

Throughout the world, increased attention is being paid to the promotion of out-of-school activities in the fields of science and technology. In Unesco's programme, this attention is reflected in the provision of support for a wide range of activities such as science clubs, fairs and olympiads, the popularization of science and technology through mass media, museums and science centres, the launching and evaluation of pilot projects and the training of personnel concerned with organizing such activities.

This publication presents a broad picture, on an international scale, of these various activities. It is intended as a source of ideas and of practical guidance for school authorities, science teachers and all others involved in out-of-school science education. It contains examples from all regions of the world.

Contributions have been obtained from many sources in preparing this book, but Unesco would like to thank in particular the following authors who have made substantial contributions: Dr Ludmila Belayeva, Chair of Pedagogy, Odessa State University, Odessa, Union of Soviet Socialist Republics; Jacob John, formerly Junior Engineers, Technicians and Scientists (JETS) Secretary, The University of Zambia, Lusaka; Edward G. Sherburne, Jr, Director, Science Service, Inc., United States of America; Nicolas Skrotsky, scientific journalist; M.J. Ormastroni, formerly Executive Director, Instituto Brasileiro de Educação, Ciência e Cultura (IBECC), Brazil; Prof. Roger Otthiers, Secretary General of the International Coordinating Committee for the Presentation of Science and the Development of Out-of-school Scientific Activities (ICC); and M.A. Fekih, Director, Jeunes-Science Tunisie.

Material has also been drawn from the *Manual for the Promotion of Scientific and Technological Activities for Young People*, published in 1984 by the Unesco Regional Office for Education in Latin America and the Caribbean (OREALC), and from other Unesco reports and documents.

The book was compiled by D.G. Chisman, Secretary, International Council of Associations for Science Education (ICASE) to whom special thanks are due.

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Introduction

The importance of non-formal and out-of-school programmes and activities in science and technology is borne out by the fact that they serve a wide variety of educational objectives relating to a varied clientele. This includes schoolchildren (through enrichment activities which supplement school syllabuses), early school leavers and dropouts (in remedying gaps in scientific and technological knowledge and skills), special professional groups (in providing scientific and technological information specific to their occupational needs), the general public (in promoting the understanding of scientific and technological developments) and scientists themselves (in keeping them informed about areas of science and technology outside their own fields of specialization). This importance is reflected in the wide range of meetings and workshops, arranged nationally and regionally over the last few years, to discuss aspects of out-of-school science and technology and to exchange information on activities and programmes.

For its content and examples, this sourcebook has drawn considerably on the reports of meetings convened by Unesco Regional Offices for Education and on papers submitted by acknowledged experts in various countries. Chapter 1 is concerned with general developments in the field, including the recent history of out-of-school science and technology education, and with the variety of tasks which can be undertaken through out-of-school science activities. The next four chapters describe various activities and programmes in out-of-school science and technology education, including clubs, societies and congresses for young scientists, science fairs, and project work, olympiads and other contests, visits, science camps and excursions. Chapter 6 is concerned with the popularization of science through the mass media, and science museums and centres. Chapter 7 looks at some general issues and trends. It also deals with aspects of training leaders for out-of-school science and technology education and with the evaluation of programmes.

The concluding chapter contains a case study of how out-of-school science and technology education is organized in one developing country, Zambia, through the Junior Engineers, Technicians and Scientists (JETS) organization. A number of appendices give further details of science clubs, science fairs, projects and olympiads for the benefit of those faced with the task of organizing such events for the first time.

1. Background

The nature of science and technology

Science, and its applications through technology, represents one of the great expressions of mankind. Every individual in the world is affected to some extent by aspects of this field of human endeavour. Every country requires trained scientists and technologists to assist with its overall development, particularly social and economic development, and to help improve the quality of life for its citizens.

Science is a way of knowing about the world and of studying the relationships, laws, principles and patterns that characterize the physical and biological environment, and the natural world in general. It is also a process or method through which certain skills, both manipulative and mental, are acquired. Technology is concerned with the applications of science, the solving of practical problems and the development of knowledge for useful purposes.

In a global context, the impact of science and technology upon the individual is variable, and quite uneven as between the richer and poorer countries of the world. The benefits conferred by science and technology on the quality of life of individuals and nations are also uneven. Some influences of science and technology, particularly in the military field, are not directly beneficial at all; other influences, for example in the field of drugs and pharmaceuticals, may have adverse as well as beneficial effects; while still others, such as those bringing about environmental changes, may give rise to public concern over pollution and the conservation of wildlife and natural resources.

One of the principal features of scientific and technological progress today lies in the fact that it is shaped less by isolated scientific achievements than by the incorporation of the results of scientific research into all spheres of engineering and technology. Moreover, the ever-increasing sophistication of research and development on the one hand and production technologies on the other has radically reduced the time gap between the making of a scientific discovery and its exploitation. In this respect, it is interesting to contrast past rates of reaping technological benefits with those of the present. One might cite, for example, telephone communications, whose technical mastery required some fifty-five years, radio (thirty-five years), television (thirty-four years), and the automobile (twenty-seven years): compare these with the lag times of atomic energy (nine years) and semiconductors, integrated circuits and lasers (just five years) for each technology to become established.

Science and technology education

Because of the all-persuasive influence of science and technology on society, it is unthinkable that science should not be part of education. Even at the primary level, many education systems now incorporate science into the curriculum. Secondary schools in all countries give high priority to science education, and a university or higher education system that does not offer science, technology and engineering as major areas of study cannot be imagined.

Despite this recognition of science as an integral part of the formal education system in all countries, the actual availability of science education is often limited by various factors. It may not be available to all students; in many countries, moreover, not all potential learners receive formal education. Alternatively, the facilities and resources for teaching science may be limited, and the teachers may not be available or are insufficiently prepared to teach science. Furthermore, only certain aspects of science are perhaps included in the syllabuses, and the applications of science through technology into problem-solving and design areas may be severely limited. These limitations of science education in the formal education system raise the issue of out-of-school science education and underline the importance of this extra dimension.

Whether through formal education systems or in out-of-school or non-formal programmes, the importance of science and technology cannot be over-emphasized. The acquisition of a minimum of scientific literacy for all can, however, mean different things at different times and in different places, depending on the nature of the target groups for which the activities are organized. It should, nevertheless, include three basic aspects of science education: knowledge (facts and information), skills (mental and manipulative) and attitudes or values. This last aspect should reflect science as a spirit of inquiry and a problem-solving activity. It also incorporates the ethical or social aspects of science. These are important both for future decision-makers and future scientists and technologists.

Out-of-school science and technology education

Out-of-school science and technology education has many parameters: those of location, time, human resources and communication, and of the learners or recipients themselves.

Locales for out-of-school science and technology education activities include homes, community centres or clubs, factories, shops, farms, deserts, beaches, seas, rivers, highways, forests and many others, as well as institutions of education.

The time available for formal education is carefully prescribed through timetables and other constraints of the school day. For out-of-school activities, the time dimension is important because such activities can extend over the whole day and hence be scheduled to suit the recipients.

Human resources for teaching represent another parameter of out-of-school activities. Here the whole array of scientists and technologists in a particular country can, theoretically, be harnessed to support the work of teachers. Moreover, agriculturalists, industrialists, craftsmen and technicians, as well as other experienced adults in the population, can all be used as human resource material for out-of-school work.

Communication is a key element in any educational activity. In the formal school situation, it is usually dominated by oral and written methods, supported by audio-visual aids and occasional experimental work. For out-of-school activities, much greater use can be made of direct experiential learning and the communication power of the mass media.

The most important element, however, is the recipient or learner. Some countries have a high percentage of the school-age population actually in the formal school system. The majority of countries, however, especially in the developing world, have large proportions of their school-age populations who are not at school, and never will be. Even those children who attend school may only receive the barest contact during the elementary grades, and thus may have no real opportunity to learn or experience any science or technology. Consequently, the potential for out-of-school science and technology education is enormous, ranging from the vast numbers of adults to the large numbers of school-age learners who have had no formal education or inadequate contact with science education.

The nature of out-of-school science and technology education should be such that it both complements and supplements science education in school. It should include those activities that are not easily provided at school, and also those that the constraints of the curriculum or time usually exclude.

The essence of out-of-school activities

There is a wide range of potential activities in out-of-school science and technology education. These activities will be described in detail in subsequent chapters, but, in summary, they can be divided into the following types: science centres; science museums; science and technical clubs, and science circles; science societies and associations for young people; nature and field centres; science camps; olympiads; science exhibitions; science fairs; project and research work; apprenticeship and intern programmes; excursions and guided visits; and congresses, lectures and meetings.

> The activities may be further sub-divided into various levels depending upon their degree of complexity, the science club being the simplest and most straightforward category... In addition to clubs, the first level includes fairs and competitions which normally represent initial activities that stimulate the massive participation of children and young persons. They tend to be very popular events in which the school and the community may take a prominent part.
>
> The second level includes conventions, contests, excursions and camping events which attract young people wishing to experience different activities and incentives close to the typical spheres of occupation of the scientist...
>
> The third level includes periods spent in scientific research or technological development laboratories and field visits accompanying scientific or specialized personnel. These activities enable a small group of young persons selected in the preceding levels to experience direct interaction with the scientist or specialist carrying out his own work (OREALC, 1984, p. 5).

The factors which restrict the development or extension of these activities in many countries are broadly organizational, financial or, in some cases, community factors such as supporting services. These factors, together with the vital aspect of training personnel for out-of-school science and technology education, will be analysed in more detail in the following chapters.

Some basic principles

Scientific and technological activities for young people should fulfil the following basic principles:

> Freedom of participation: i.e., respect for the will of children and young people in respect of involvement in these undertakings, and consideration of their interests, curiosity and aspirations in carrying them out.
>
> Educational orientation: all juvenile out-of-school scientific or technological activities should respond to an educational purpose.
>
> Equality of opportunity: namely the opportunity of participation in out-of-school scientific and technological activities of all children and young people from an early age, regardless of their social circumstance or place of residence.
>
> Social integration: involving the permanent involvement and collaboration of the participants, one with another and with other members of the community.

> Interaction with scientists and technologists: i.e. the need to establish appropriate relations between the young participants on the one hand and teachers, directors, scientists, professional specialists, technicians and artisans on the other.
> Gradual participation: a logical sequence of participation commensurate with age and the acquisition of scientific and technical skills (OREALC, 1984, p. 2).

A framework for out-of-school science and technology education

A three-dimensional framework or matrix can be constructed as a guide to the interaction of the three main components: 'out-of-school', 'science and technology' and 'education'. The main divisions of the 'out-of-school' component are location, time, human resources, communication and potential recipients. The main aspects of 'science and technology' include: knowledge (facts, theories, concepts), skills (practical or manipulative, mental and

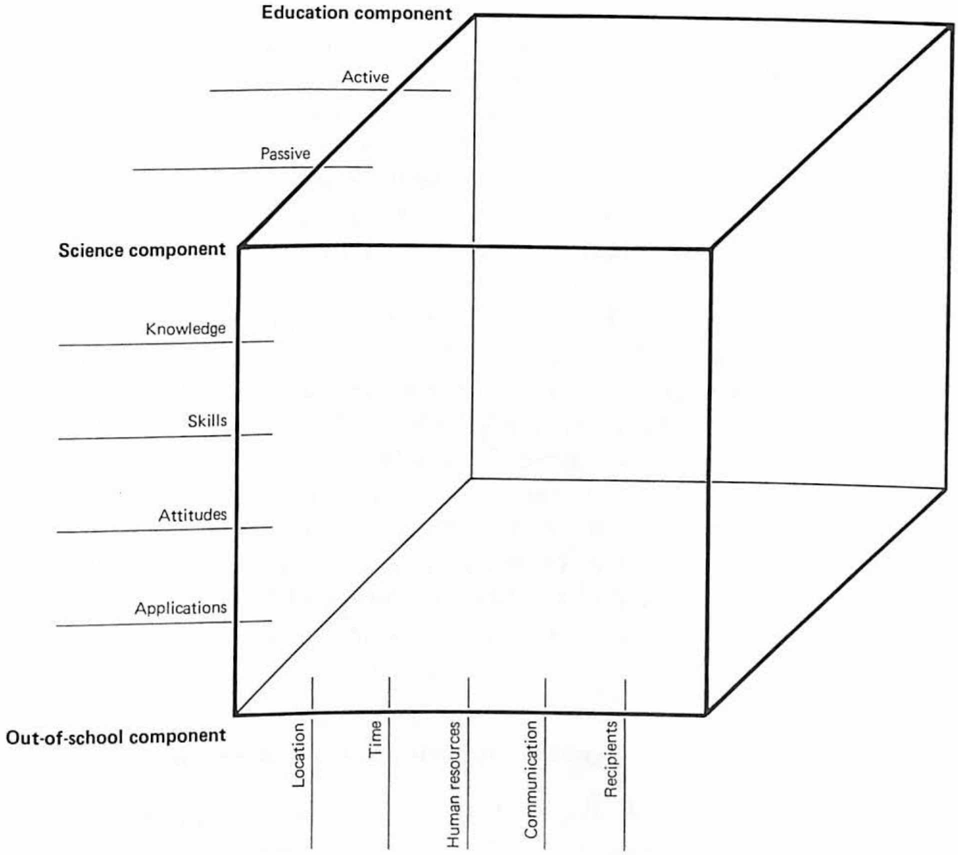

FIG. 1. Three-dimensional framework.

equipment), attitudes (personal, social) and applications (industrial, social, commercial, personal). Problem-solving and answering questions are also essential features of science and technology. The 'education' component can best be described, in this context, as passive or active learning. A learner passively listening to a lecture or watching a television programme is experiencing education in a different mode from a learner who is actively involved in a science club or science camp.

These three dimensions can be depicted on a three-dimensional model, as shown in Figure 1.

The development of out-of-school science and technology education

In some countries, especially in the developed world, and particularly in Eastern Europe, aspects of science and technology education have been available for many years through out-of-school activities such as astronomy clubs, radio clubs, young pioneer organizations and associations for the advancement of science. But it is only within the last twenty-five to thirty years that such activities have been available in developing countries, and only within the last twenty years that such initiatives have been organized on a national, regional and international basis.

The modernization of school science curricula in the 1960s, the increased interest in science and technology, the demand for participation by young people themselves and the social concerns of the general populace in matters relating to science and technology have all contributed to the development of out-of-school science and technology education. In addition to the overt tasks of such education, as described in later chapters of this book, there are other examples of out-of-school science education that emphasize the role of science in the community or that encourage creativity among young people. Out-of-school science and technology are also a valuable means of linking education with productive work, through work experience and 'on-the-job' training or apprenticeships.

Some early beginnings of organized activities and co-ordination

The possibility of establishing a European organization of out-of-school activities was first discussed at a meeting in Liège (Belgium) in 1960, arranged by the Belgian National Service of Youth, on the initiative of the Out-of-school Education Committee of the Council of Europe.

The Science Museum, London. Children can be very noisy in the museum's Children's Gallery.
(Photo: *International Council of Museums.)*

Special events at the Lawrence Hall of Science are excellent for introducing the public to scientific concepts. Here a family meets Tyrannosaurus Rex during an event entitled 'Dinosaur Days'. (Photo: *Lawrence Hall of Science, University of California.)*

The Science Museum, London, United Kingdom. Blind children need special attention when they visit the museum. (Photo: *International Council of Museums.)*

In Latin America, the Instituto Brasileiro de Educação, Ciência e Cultura (IBECC) in São Paulo (Brazil) began a survey of existing science clubs in 1952. Later, it sponsored the first Brazilian Science Contest in 1958 and the first Brazilian Science Fair in 1960.

The first outline of a programme of international co-operation was discussed at a seminar organized by Unesco at the Institute of Youth, in Gauting, Bavaria, in May 1962; an interim co-ordinating committee, with its headquarters in Brussels, was subsequently established by Jeunesses Scientifiques de Belgique. This early period was characterized by efforts to improve co-ordination among existing organizations, to increase the quantity and quality of out-of-school activities and to encourage exchanges of people.

The International Coordinating Committee for the Presentation of Science and the Development of Out-of-school Scientific Activities (ICC) was formally established at an assembly held in Strasburg (France); it was granted consultative status (Category B) by Unesco in May 1967. ICC's first international conference was held in Montreal (Canada) in August 1967; its statutes were formally agreed upon at a meeting in Tunisia in November of the same year.

The birth of ICC stimulated considerable activity in many regions of the world. In Latin America, for instance, IBECC organized the first Latin American seminar on out-of-school science programmes, held in São Paulo in 1968, and in 1969 came the first seminar on the popularization of science (also held in Brazil). Both these seminars were sponsored in part by Unesco.

Regional secretariats for ICC were established in São Paulo for South America, in Calcutta (India) for Asia, in Tunisia for the Arab States, and in Manila (Philippines) for South-East Asia. The Belgian Government continues to support the small ICC Secretariat in Brussels, while Unesco and the Council of Europe continue to provide professional and financial support for ICC projects, publications and field activities.

Meanwhile, the number of national associations which are affiliated to ICC and concerned with out-of-school science education, fourteen in 1968, doubled in four years. There are now more than one hundred members of or correspondents with ICC throughout the world.

The *ICC Information Bulletin* is published in French, English and Spanish; it first appeared in printed form in 1970, having been produced as a stencilled news-sheet from 1968 to 1970. By 1985 twenty-four issues had been published. ICC also publishes the *Calendar of Youth International Scientific and Technical Activities,* and a number of occasional booklets on specific topics. In 1969, under contract to Unesco, ICC prepared a handbook on *Out-of-School Science Activities for Young People* (Stevens, 1969).

Structure and administration

Principles and conditions of organizing out-of-school science and technology education activities

All out-of-school science activities and programmes should be planned and developed according to the identified needs, interests, real-life problems and concerns of the various target groups. These target groups may be broadly defined as follows:

1. The formal school population, who need out-of-school activities designed to enrich, supplement and complement school science education curricula.
2. Out-of-school youth and adults (early 'dropouts' from school, illiterates, general workforce), who need activities designed to develop a basic sciencific literacy, to create interest and to form an appropriate, relevant scientific climate of opinion.
3. 'Educated' youth and adults for whom out-of-school activities should be part of a lifelong education, designed to clarify changing socio-economic and cultural conditions and rapid changes in the applications and relevance of scientific and technological ideas and developments.

Some of the identified needs are apparent and of regional relevance; they include population control, the fight against malnutrition, the increase of agricultural productivity, and the improvement of livestock, health and sanitation. Other needs will be more specific to local communities. Once the needs and target groups have been identified, priorities will have to be determined, and these will be dependent, to some extent, on the available resources – physical, financial and human. Other aspects which will affect the choice of priorities will be feasibility, attainability and acceptability by the community in the light of relevant social and cultural backgrounds and conditions.

Organization and implementation

Most out-of-school activities in science and technology are organized along one of the following lines: educational work, technical activities, or environmental and nature protection work. The organizational form of the activities may be: individual work with students; group work, such as activities in the context of clubs and societies; broader activities, including olympiads, contests and excursions; and the popularization of science, using museums and the mass media. The implementation of specific activities is illustrated in the following chapters. The way in which many activities are organized and implemented in a particular country is exemplified in Chapter 8.

In some cases, the organization and implementation of out-of-school

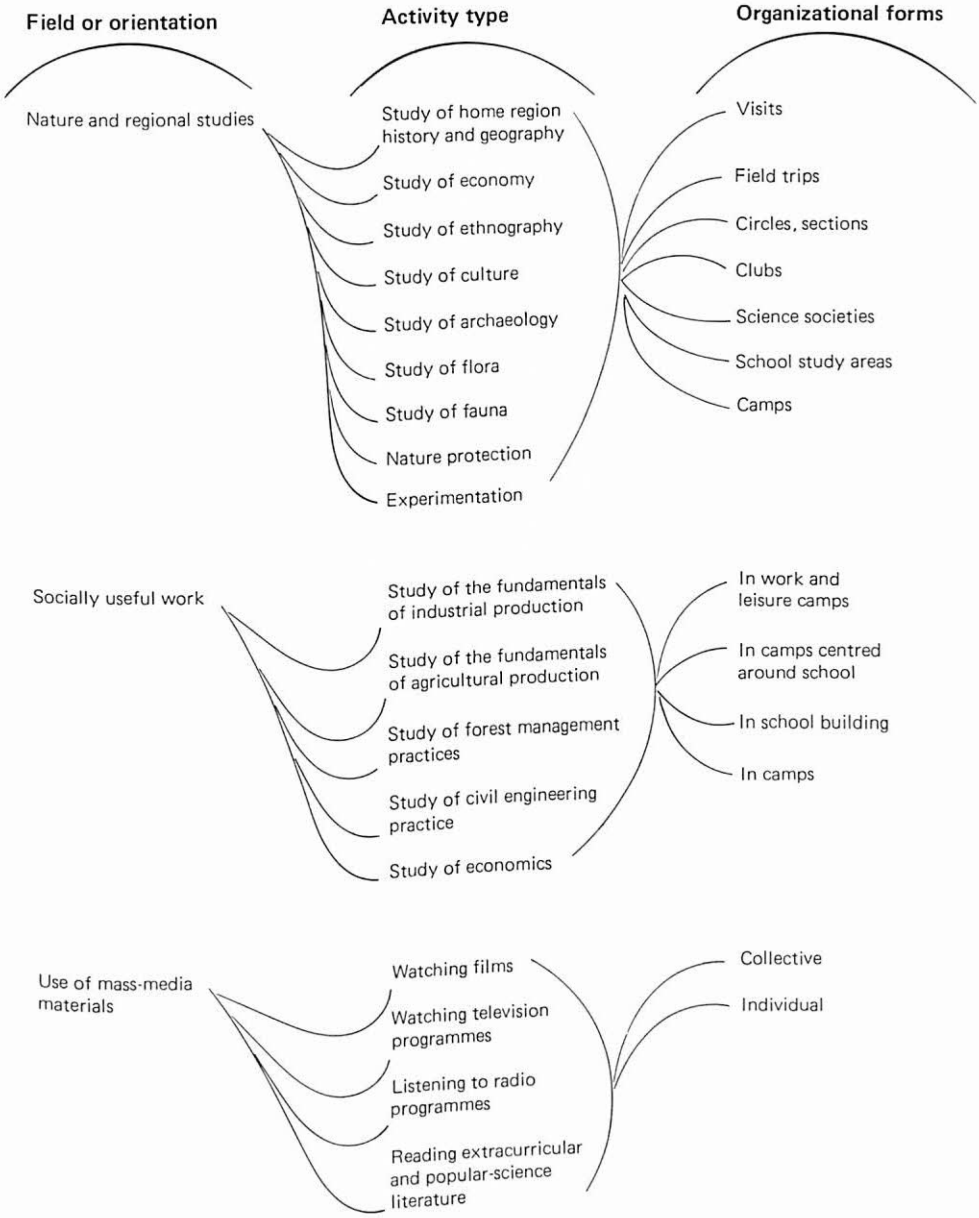
Field or orientation
Activity type
Organizational forms
Nature and regional studies
Study of home region history and geography
Study of economy
Study of ethnography
Study of culture
Study of archaeology
Study of flora
Study of fauna
Nature protection
Experimentation
Visits
Field trips
Circles, sections
Clubs
Science societies
School study areas
Camps
Socially useful work
Study of the fundamentals of industrial production
Study of the fundamentals of agricultural production
Study of forest management practices
Study of civil engineering practice
Study of economics
In work and leisure camps
In camps centred around school
In school building
In camps
Use of mass-media materials
Watching films
Watching television programmes
Listening to radio programmes
Reading extracurricular and popular-science literature
Collective
Individual

FIG. 2. System of educational activities for school-age young people.

activities are initiated by a government department; in other cases, the activity may emerge from a 'grassroots' initiative. In every case, however, the development and implementation of activities will involve the careful consideration of a number of factors. These factors will vary according to the nature of the activity, and not all factors will be relevant to all projects or activities, but the summary that follows will give a typical blueprint or checklist from which the organizers can plan the desired activity. The factors are: finance and budgeting; transport; community involvement; co-ordination and liaison with other organizations; administration and overall co-ordination of project; use and involvement of the media; publicity and public relations; liaison with schools and local education authorities; involvement with families; involvement of industry and commerce; public liability – insurance; obtaining equipment and materials; and accommodation for project or activity.

For every project or activity, it will be necessary to prepare a budget. Among the areas of expenditure are: cost of accommodation; transport; printing/duplication/stationery; staff; graphic design; heat or air conditioning, light, power, fuel; postage; insurance; purchase of equipment – expendable and non-expendable; telephone; photocopying; cost of prizes; travel expenses; hospitality; publicity; photographs/audiovisual aids; and donations.

The income for meeting this expenditure may be provided by national or local government departments, by national and international agencies, through donations or grants from industry, banks and commercial organizations, and through direct charges for specific events, the sale of programmes and refreshments.

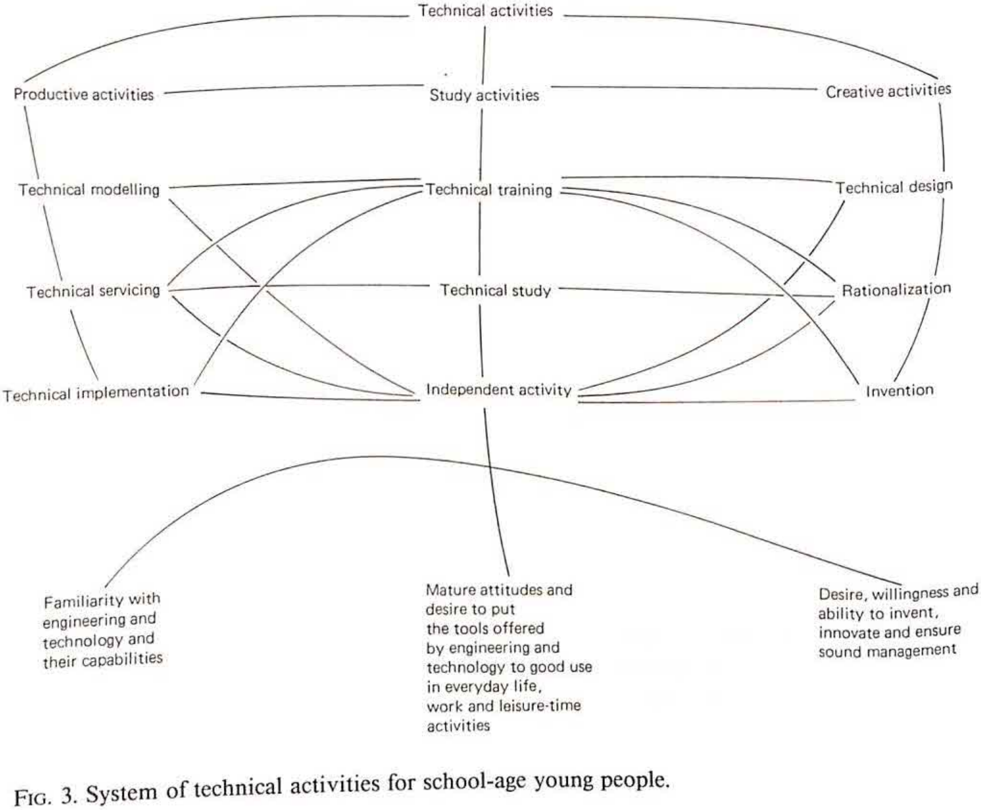
Technical activities
Productive activities
Study activities
Creative activities
Technical modelling
Technical training
Technical design
Technical servicing
Technical study
Rationalization
Technical implementation
Independent activity
Invention
Familiarity with engineering and technology and their capabilities
Mature attitudes and desire to put the tools offered by engineering and technology to good use in everyday life, work and leisure-time activities
Desire, willingness and ability to invent, innovate and ensure sound management

FIG. 3. System of technical activities for school-age young people.

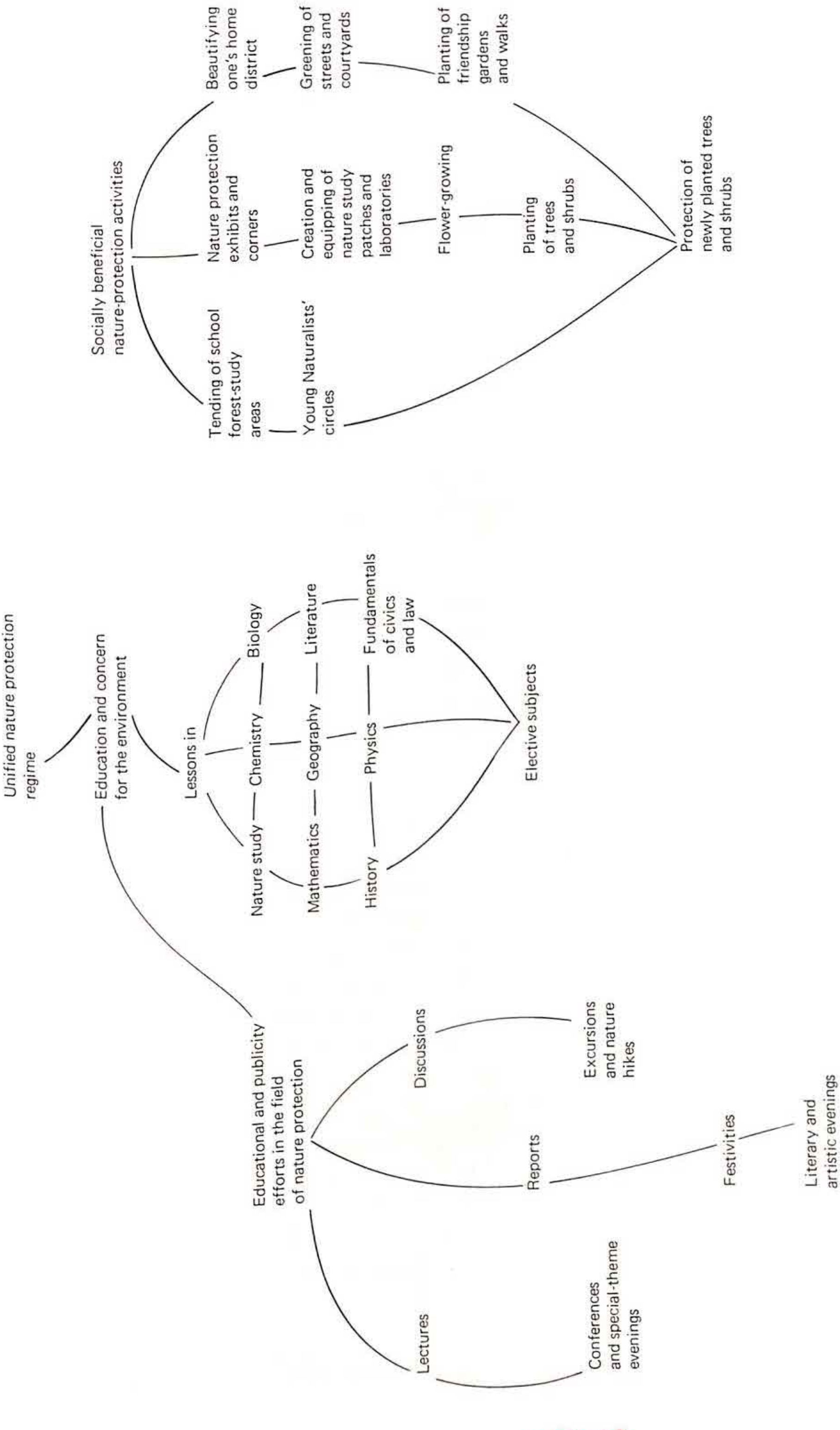
Unified nature protection regime
Education and concern for the environment
Lessons in
Nature study
Chemistry
Biology
Mathematics
Geography
Literature
History
Physics
Fundamentals of civics and law
Elective subjects
Educational and publicity efforts in the field of nature protection
Lectures
Conferences and special-theme evenings
Reports
Festivities
Literary and artistic evenings
Discussions
Excursions and nature hikes
Socially beneficial nature-protection activities
Tending of school forest-study areas
Young Naturalists' circles
Nature protection exhibits and corners
Creation and equipping of nature study patches and laboratories
Flower-growing
Planting of trees and shrubs
Beautifying one's home district
Greening of streets and courtyards
Planting of friendship gardens and walks
Protection of newly planted trees and shrubs

FIG. 4. System of nature protection activities for young people.

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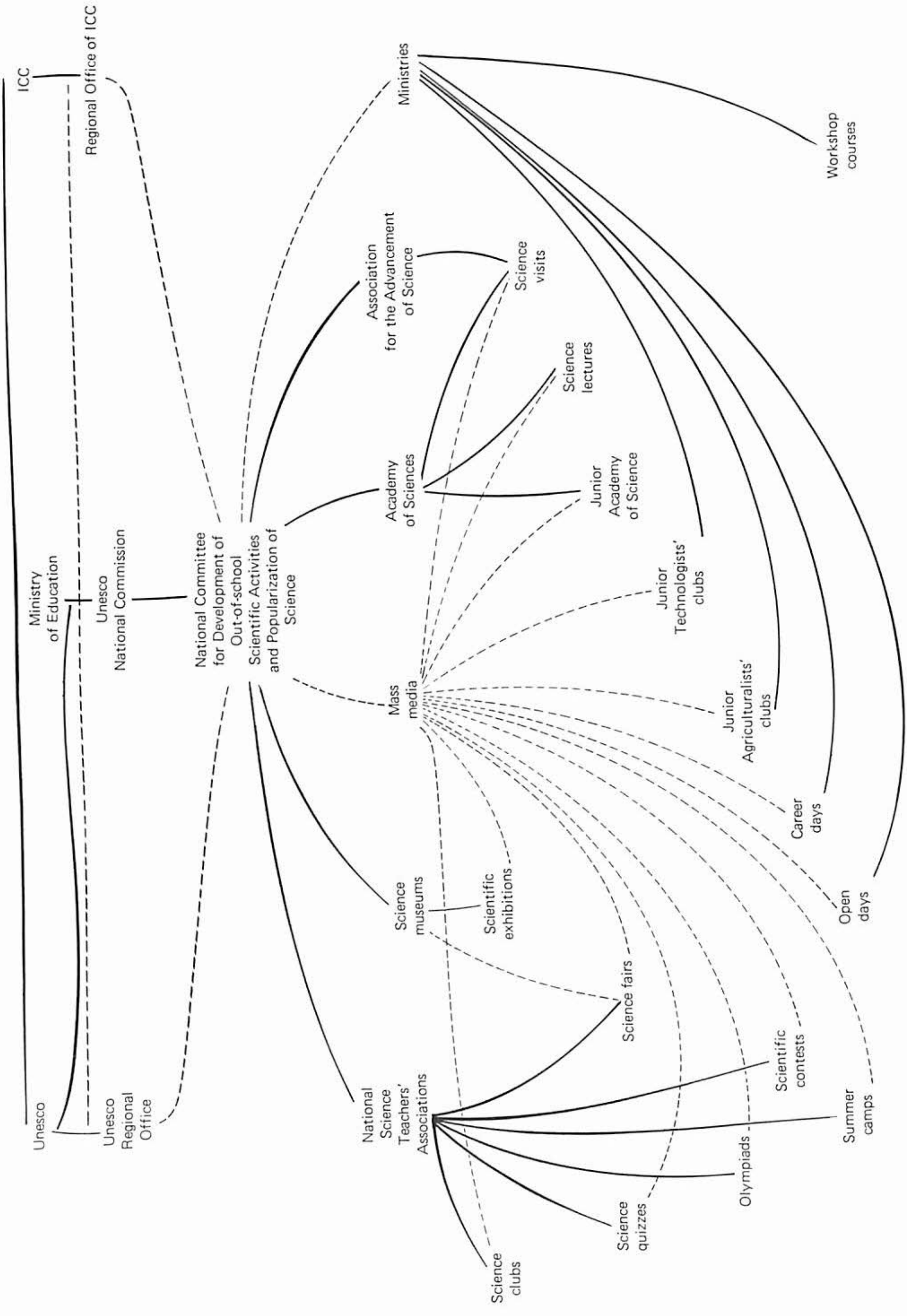

FIG. 5. Scheme of structure for co-ordination of out-of-school scientific activities. (After *Out-of-School Scientific and Technical Education* (Brussels, ICC), No. 16-17, p. 34.)

The checklist, and the items of expenditure listed above, can be incorporated into a chart with one set of factors being plotted on a horizontal axis, the other on a vertical axis. This would provide a ready-at-a-glance assessment of the important components for any specific project. For example, the transport factor would involve staff, fuel, insurance and consumable equipment (spare parts).

Local and national organization

Out-of-school activities may be organized at local or national level, in many countries, and by a variety of agencies, institutions and individuals. In some countries, the organization, both nationally and locally, lies is in the hands of ministries and government departments; in others, the responsibility lies with private and public agencies, voluntary organizations and individuals.

It is highly desirable that the appropriate co-ordination and co-operation be established in order to make full use of the resources and expertise available. To achieve this, it may be necessary to create an infrastructure or to utilize an existing infrastructure at national, provincial, district or local level. During the last decade or so, many countries have established national science museums or science centres; others have set up Ministries of Youth. These, together with the appropriate departments of Ministries of Education, could provide the necessary planning and co-ordination at national level.

International co-ordination

The importance of an international structure for out-of-school science and technology education is illustrated by the following considerations:

The right of all countries to receive information on all aspects of out-of-school science and technology education.

The need to provide co-ordination among countries, at the international level, for activities in out-of-school science, including the sharing of ideas and the effective training of leaders.

The need to provide a voice at the international level, without the constraints of politics, religion or other factors, to promote and develop programmes in out-of-school science and to disseminate information.

Such a structure, as exemplified in Figure 5, is provided by ICC.

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2. Clubs, societies and congresses

Science clubs

A science club is an association of young people, with one or more adult sponsors, organized to carry out extra-curricular science activities. Clubs may be at the elementary or secondary level, and the number of members can range from a few to several hundred. The 'club' emphasis may be quite specific and limited to one field such as astronomy, engineering or rocketry, or it may cover all aspects and applications of science. Clubs are most often school-based, but they may be organized at a museum, a science centre or any other appropriate location. In some countries, e.g. the Union of Soviet Socialist Republics, the science club is usually called a 'circle'. Meetings may be held during school hours, after school or at weekends.

Types

Various factors influence the nature of a science club, the principal ones being the area of interest adopted by the club at its formation and, subsequently, the age range of its members and the sponsorship it enjoys. These factors are worth discussing.

Area of interest. This means, in other words, the kind of science to which the club will devote its attention. This may range from general science – biological and physical – to special interests such as astronomy, agriculture, electronics, ornithology and mineralogy, and to applied science or technology. The choice of the area or scope is usually determined by the club's organizers. It should be defined as soon as possible so as to attract similarly interested members. The area of interest will usually determine the initial size of the club.

Special fields of science will usually attract only a limited number of members. But a speciality club is relatively easy to organize and manage, because the members will share similar interests and goals, and the meetings and activities can be informal.

Clubs which cover broad fields of science usually attract more members and should therefore maintain a more formal organization and programme in order to accommodate the various interests of the membership. In all cases, however, care must be taken to ensure that the formalities of club meetings extend only so far as to meet the needs of the organization, thus keeping the focus of attention on the activities.

Age level. Children show a natural interest in science at a very early age, and it is possible to nurture curiosity as early as kindergarten level. Slightly older, elementary-grade children respond enthusiastically to an organized science club when the programme is designed to meet their level of interest and knowledge of science. At the secondary school level, there are more sophisticated programmes which allow students to assume leadership in the planning and operation of club activities.

Adult sponsorship. Most clubs in schools are organized as an extra-curricular activity, with one or more teachers serving as sponsors and advisers to the club. Some schools may have more than one science club to accommodate special science interests and to keep membership at a manageable level.

There are also a large number of science clubs organized by institutions other than schools and sponsored by organizations such as museums, zoos, employee organizations of science industries and youth organizations. In some cases, individual scientists have formed neighbourhood science clubs for the interest and benefit of children. There are also clubs which are organized as separate entities with their own buildings and staffs, either voluntary or paid. Such clubs can vary from a one-room cottage (for a nature club) to a building with meeting rooms, a library, an observatory, laboratory space and storage rooms.

Purpose

Science clubs can be extremely varied, as they adapt to the interests and abilities of their members and their sponsors. Clubs vary from school to school, or even from year to year within the same school, changing with membership, the potential of the community, and the abilities and interests of advisers and members. All clubs, however, should have certain general purposes which are more or less the same despite the individual differences. These purposes include:

The development of activities which contribute to a better understanding of science and its applications on the part of the club members.

The increased interest in science and its applications on the part of the members (club activities may be more interesting to members than the formal curriculum in a school, and through the activities, students may become more interested in science).

An increase in the time available for learning, by providing activities after school or at weekends (school hours are not the only time when science can be studied, and club activities can increase learning time substantially).

The development of a sense of involvement in and identity with group undertakings.

A better understanding of science as a career (activities such as working in laboratories, visiting factories and going to farms provide students with a more realistic understanding of what various careers are like).

A better understanding of the function of science in modern life and in national development.

The involvement of adults other than teachers in the students' learning process.

Organization

The requirements for the organization of a science club include interested adult sponsorship to provide leadership, a group (large or small) of interested members, an accepted area of science on which to focus, a place to hold meetings, some set of rules describing how the club will be run, and a plan of activities.

All science clubs require rules describing who will govern the club and how. These rules are usually embodied in a constitution, which may include a philosophical statement of purpose, criteria of membership, duties of officers and the structure of meetings (see Appendix I).

Smaller clubs usually function with a minimum of structure – often with little more than an effective leader. The larger clubs will require more detailed organization. Their officers may include a president, vice-president, secretary, treasurer and perhaps a librarian, reporter, recruiter and director of activities. They may also include a number of committees responsible for specific duties or activities.

The secretary, or some other specially appointed person, should keep records of all the club's transactions. Records provide good material for training new officers, establishing policies and determining activities in succeeding years.

Although it is not essential for a club to have a constitution, a specimen constitution for a school science club is given in Appendix I. This can be modified as desired.

Sponsors

Most science clubs will have an adult sponsor, usually a teacher. The role of the sponsor may take either one of two distinct forms: that of organizer of a new club or that of adviser for an ongoing club.

Organizing a new club. The decision to organize a new science club may originate with students who want such a club or with the sponsor (or other adult) who feels that a club is needed. The decision should be based on a consideration of the following issues:

Is there a need for a club? Is there another club already in existence? Have there been clubs in the past? Do students seem to be interested?
Are there any regulations in the school (or elsewhere) that might affect the formation of the club? Does anybody have to approve the constitution?
What space and facilities are available for the use of the club? Where will it meet?
What kind of budget is needed for the club? Where will the funds come from, and can they be obtained?

The sponsor should then call the first meeting, which will be an organizational one. In the initial stages, the sponsor must establish a structure that will enable a student group to function in a flexible yet productive manner. It is here that the sponsor must use his understanding of the student population, the physical facilities and the club's potential in order to advise the leadership on setting realistic goals.

Advising an ongoing club. The sponsor of an ongoing club will be less directly involved. He should serve as an adviser, helping when needed. But it should be emphasized that while the adult sponsor is vital to the success of a club, he cannot and should not be expected to do all the work. Nevertheless, the sponsor must be willing to give generously of his time. He should have a real interest in and knowledge of science, as well as an interest in club activities. Enthusiasm is contagious, but so is a lack of enthusiasm. It requires continued stimulation to keep a club going, and an important part of this comes from the sponsor.

Activities

Members of science clubs engage in many different kinds of activities arising out of the interests of the individual members and of the club itself. In some cases, the activities are directly related to the club and are run by it. In other cases, the club may provide the impetus to engage in the activity, but is not involved any further.

Meetings. The key element in the functioning of a science club is the meeting. Meetings serve at least three purposes. First, they provide a means of taking care of club administration (programme decisions, membership, dues, fund-raising, publicity, etc.). Second, they permit programme planning and committee feedback (concerning programmes ranging from science fairs to bulletin boards). Finally, they provide a time for educational and informational activities (lectures, demonstrations, book reviews, etc.).

An important decision concerns how formal the meetings should be. This will probably relate to the number of members who attend. Obviously, a meeting with five people present will be run somewhat differently from one with fifty. In order to systematize the planning of meetings, there should be some agreement on at least the following:

Frequency of meetings: are they to be weekly, semi-monthly, monthly or on call?
Length of meetings?
Location: it is generally easier always to hold meetings in the same location, but this may be affected by the number of persons attending a particular meeting, or by special requirements such as the ability to darken the room in order to show films.

Research. A core programme of the science club should involve the participation of the more scientifically minded members in research projects. Occasional visits by scientists, research presentations by other students, the sponsor's explanation of research techniques, and so on will be of interest to most members.

Research may include laboratory, field or theoretical investigation in any area of science, engineering, mathematics or medicine. It can consist either of individual work done by a single student, or of a team effort or a group project undertaken by perhaps fifty or more members. Individual projects might, for example, include growing irradiated seeds, building a computer, constructing a telescope or surveying the bird population. Group projects, on the other hand, could include ecological surveys, gathering data on pollution, studying the ecology of the local area or constructing a rocket.

Field trips. Visits to points of local scientific interest are both popular and valuable in the development of a club programme. Such trips might be made to college or university laboratories, farms or agricultural research stations, wildlife sanctuaries, museums, research laboratories, industrial plants and their laboratories, mines, hospitals and medical research facilities, and fish hatcheries.

Club projects. The science club should ideally have some projects of its own which involve some or all of the members. If some of the projects are of the type that can be continued from one year to the next, they can provide continuity, even though the members may change. Examples of school projects are:

Science fair: organize a school science fair – it is an excellent means of encouraging students to do research, and of attracting attention to the work done by club members.

Science library: form a science library to be used by club members, other students and the public.

Science careers information: gather and keep information on science careers for those who might be interested.

Research titles: keep a record of all the projects carried out by members.

Examples of community projects are:

Research: conduct research for the community into some problem on which information is needed – pollution, pest control, water supply, conservation, etc.

Exhibits: prepare exhibits to be placed in public places – shop windows, public buildings, libraries, etc. – about some aspect of science that is of interest to the public.

Weather: establish a weather station, keeping a record of conditions and making them available to the public.

Astronomy observation: have a night for the public to use the club telescope.

Plants: start a garden to grow plants that can later be placed elsewhere to beautify the community.

Publicity

Publicity for the science club is essential. This can be achieved in a variety of ways, including a club newsletter, club magazine or club noticeboard and through parent evenings, exhibitions and other special events. Publicity through local newspapers and radio is also important.

Problems

Among the problems in organizing and maintaining a science club the following are significant:

Demands on the time of student members; members may have other commitments and not be able to devote their time and energy to the activities of the club.

Shortage of suitable adult sponsors.

Financial problems.

Physical facilities – lack of suitable accommodation for the range of activities desired.

Junior science societies and associations

A junior science society, academy or association is an organization with a broad geographical membership made up of young people, usually at the pre-university level, who have a common interest in out-of-school scientific activities. It may be a junior association with a broad interest in science or engineering, or it may have very specific common interests, for example, a junior physics association or a junior ecology association.

Junior associations are usually national in scope and are generally much larger than clubs. In fact, they are most often made up of a network of clubs which are affiliated to the national organization. Most activities are carried out at the local level through the clubs, but an important aspect of junior associations is that they also involve regional or national activities.

There are two general types of junior association. One is a junior association that forms part of an adult science association. Thus a national science association might form and administer a junior national science association for young people. The other type is an independent junior national science association that is not part of any adult science association. Such a junior association might be formed by a group of interested scientists and operated as an independent entity.

Most junior science associations are national in scope, and they tend to be organized at three levels – national, regional and local. At the national level are to be found the headquarters or central office staff, consisting of one or more adult professionals. The actual size of the staff will depend on the type of programme and the funds available. The staff has responsibility for administering national activities (meetings, contests, etc.), for co-ordinating regional activities, and for providing services for regional and local groups.

Many national associations have offices for geographical regions. These offices, if they exist, form an intermediate tier. They usually have part-time or volunteer staff (or committees) which perform whatever duties are needed, calling upon the national staff for assistance when necessary.

Most junior associations are actually networks of clubs, so that members of

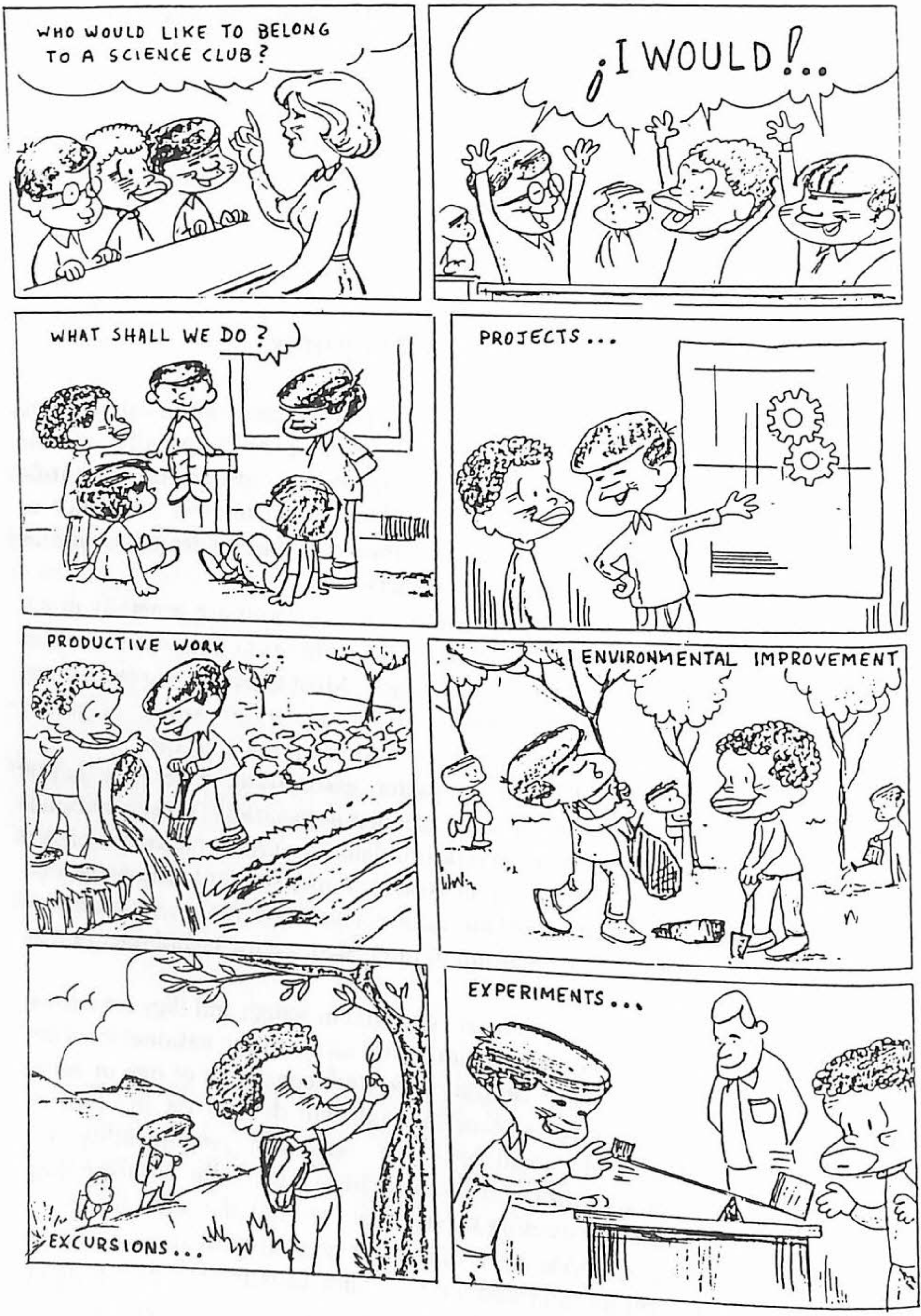
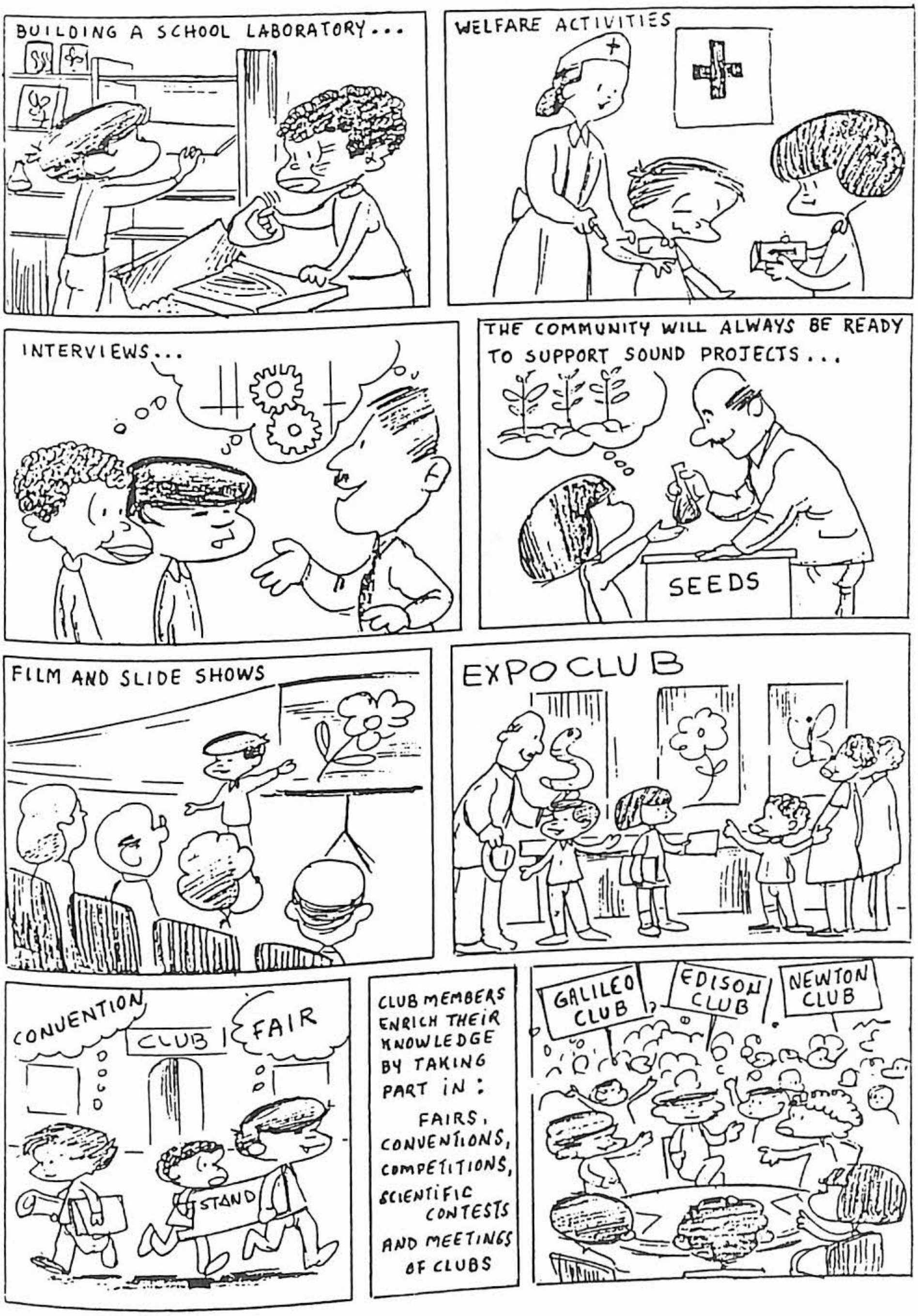
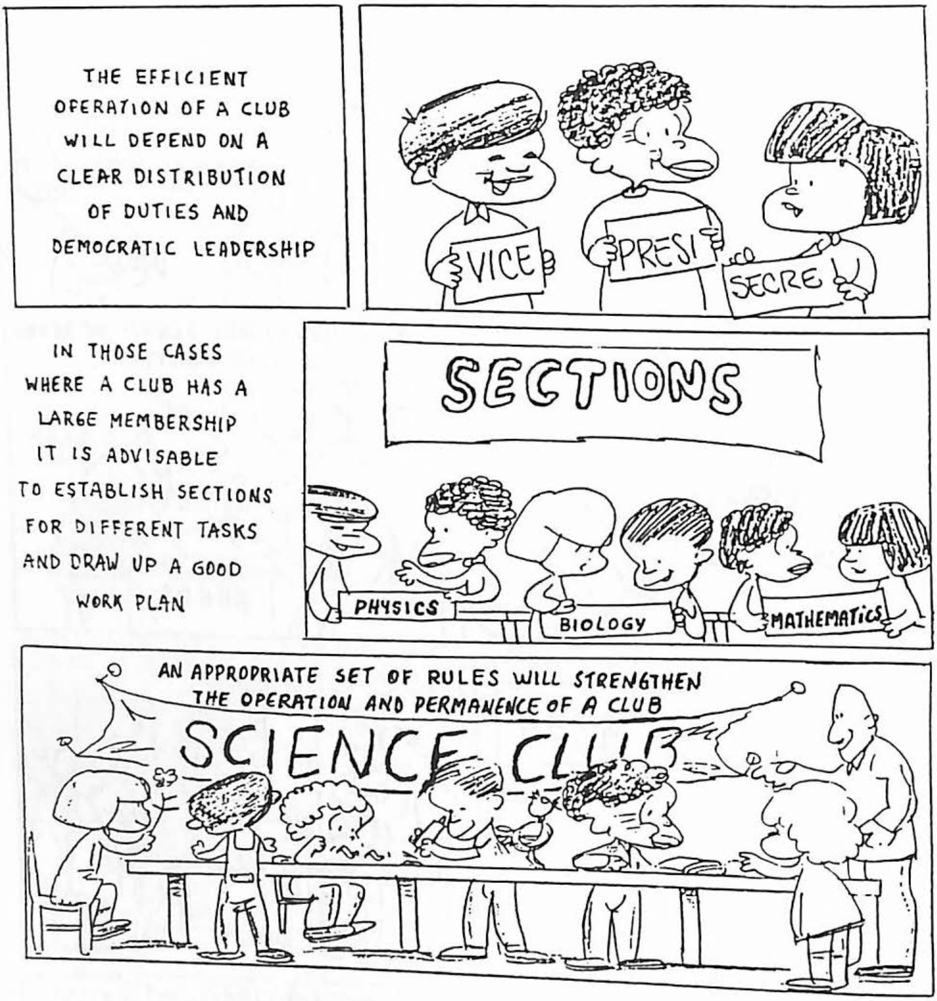

WHO WOULD LIKE TO BELONG TO A SCIENCE CLUB?
¡I WOULD!..
WHAT SHALL WE DO?
PROJECTS...
PRODUCTIVE WORK
ENVIRONMENTAL IMPROVEMENT
EXCURSIONS...
EXPERIMENTS...

FIG. 6. A club: illustrated summary.
Source: OREALC, 1984, pp. 18-20.


BUILDING A SCHOOL LABORATORY...
WELFARE ACTIVITIES
INTERVIEWS...
THE COMMUNITY WILL ALWAYS BE READY TO SUPPORT SOUND PROJECTS...
SEEDS
FILM AND SLIDE SHOWS
EXPO CLUB
CONVENTION
CLUB
FAIR
STAND
CLUB MEMBERS ENRICH THEIR KNOWLEDGE BY TAKING PART IN: FAIRS, CONVENTIONS, COMPETITIONS, SCIENTIFIC CONTESTS AND MEETINGS OF CLUBS
GALILEO CLUB
EDISON CLUB
NEWTON CLUB


THE EFFICIENT OPERATION OF A CLUB WILL DEPEND ON A CLEAR DISTRIBUTION OF DUTIES AND DEMOCRATIC LEADERSHIP
VICE
PRESI
SECRE
IN THOSE CASES WHERE A CLUB HAS A LARGE MEMBERSHIP IT IS ADVISABLE TO ESTABLISH SECTIONS FOR DIFFERENT TASKS AND DRAW UP A GOOD WORK PLAN
SECTIONS
PHYSICS
BIOLOGY
MATHEMATICS
AN APPROPRIATE SET OF RULES WILL STRENGTHEN THE OPERATION AND PERMANENCE OF A CLUB
SCIENCE CLUB

the association are also members of the local section or affiliate. The affiliates are usually organized as separate entities with their own officers, adult sponsor and constitution. They conduct activities suggested by the national or regional offices; alternatively, they may develop activities on their own.

As most junior science associations attempt to be national, they try to recruit members from all parts of a country. This is not always easy, however, and representation may be quite uneven. Membership may be strong in urban areas and weak in rural areas, or the north of the country may be better represented than the south. Strengthening the membership in under-represented parts of a country is always a problem for national associations, and areas of weakness should not be considered an indication of failure on the part of the organization.

Membership in a junior science association can be on an individual basis, but it usually follows from membership of an affiliated club, section or branch. Thus a student might join a club and, by doing so, become a member of the national organization. Or a previously unaffiliated club might affiliate, and its members would thereby become members of the national organization.

Most associations have some sort of membership requirements, which can include:

Interest in the scientific area of concern to the organization.
Age: some memberships are restricted to certain age groups, with members having to be above, below or between certain ages.
Grade level: most associations are essentially made up of pre-university members, but may allow older students. Alternatively, the association may be an essentially adult one which admits younger people as well.
Academic record: some associations may only take students with good education, or require the students to be above a minimum level; some may only be open to students with the highest grades.
Evidence of having passed a required course: in some associations, such as a rocket association, would-be members may first be required to pass a course, because of the danger that an untrained person might cause.

The sources of funds for the support of a junior science association can vary from country to country and, within a country, from association to association. These sources can include:

Government: in some countries, associations are completely supported by the government.
Membership dues: these may come either from individuals or from the affiliated clubs. Where this is the case, the dues are usually not enough to provide complete support, and other sources must be available.
Business and industry: some associations may be supported completely or in part by funds donated by business or industry.

Parent science association: for the junior association that is part of an adult science association, the funds for support may come from the parent association.

The activities of junior science associations can occur at the three organizational levels: national, regional and local.

National level

Administration:

1. Central office administration: arranging meetings of the Board of Directors, preparing the annual report, handling financial matters, etc.
2. Obtaining the necessary support funds from appropriate sources.
3. Giving national publicity to programmes.

Membership:

1. Promoting drives for new members or new affiliates.
2. Keeping membership records: names and addresses of members, date of membership, other information as desired.
3. Collecting dues (if required) from members (may be shared with affiliates) and/or from affiliates (clubs, etc.).
4. Providing membership pins, certificates and T-shirts. These may be provided as part of membership or they may be sold to members.

Publications:

1. Publishing and distributing national newsletters or magazines for members, to inform them of national and regional activities and winners of contests, and to make suggestions for out-of-school scientific activities.
2. Publishing and distributing a journal containing reports of research by members.
3. Issuing a handbook on how to organize clubs. This is very important in helping to form new clubs.
4. Publishing project books: these are books (or booklets) that introduce a student to some area of science and suggest research questions appropriate to the student's level of experience.
5. Publishing reference books: how to build a telescope or rocket, for example.
6. Issuing titles of science projects undertaken by students for science fairs and science talent searches. These are useful in giving younger students ideas for projects. Such publications can have several hundred to several thousand titles.
7. Issuing a handbook on how to organize a science fair.

Contests – organizing and administering contests with national participation:

1. Sponsoring a national science fair: this is a science fair in which participants represent regional or local science fairs; it usually involves the best students from each fair.
2. Sponsoring national olympiads in physics, chemistry and/or mathematics.
3. Conducting national science olympiads.
4. Keeping records of various contests – winners, highest scores and problems set.

Meetings:

1. Administering annual national meetings of the association, which might include: sessions on association business, readings of papers by members, exhibits of projects undertaken by members, lectures by scientists and field trips.

Promoting opportunities for members to broaden their experience:

1. Disseminating information on summer research opportunities.
2. Administering a summer science camp.
3. Providing small research grants to help students pay for materials or equipment for research projects.
4. Arranging for the international participation of members in meetings, camps, etc.

Leadership training:

1. Conducting training sessions for leaders.
2. Developing handbooks and other materials that are of assistance to leaders.

Regional level

The need for a regional tier of organization will vary from country to country, depending upon size, geographical variations, communications, and so on. If a regional tier is called for, the following considerations may or may not hold good, depending upon circumstances:

Administration: this may well be carried out by volunteer staff or by a volunteer committee rather than by professional staff.

Membership: will evidently support national efforts.

Contests: regional versions of national contests can be held, or the administration of nation-wide contests can be broken up and delegated to regions. Thus there can be regional science fairs, regional olympiads, and so on.

Meetings: regional meetings can be useful, as they involve fewer travel expenses. They may provide opportunities for intercommunication that would not otherwise be possible.

Training for leaders: it may be more advantageous (easier and less expensive) to organize this at a regional level than a national one.

Local level

The activities of associations at the local level will mirror those of science clubs, described in the first section of this chapter.

Problems

The main problems revolve around membership, fund-raising and leadership.

Membership

An association cannot exist without members. Gaining and holding members probably constitute the major problem of junior associations. There are two facets to this problem – recruitment and retention:

Recruiting new members. Since the members are young people, they are generally much more difficult than adults to recruit on a national basis. As most associations are networks of clubs, efforts to generate membership are generally made by the clubs' adult sponsors. Thus there must be a steady pressure designed to encourage the sponsors to recruit new members. If the sponsors cannot be motivated to do this, the club membership will decline, and so, consequently, will the association membership.

Retaining members. Once members have been enrolled, there is still the problem of maintaining their desire to be members. This is, to a substantial degree, the responsibility of the club sponsor, stimulated by the national office through publications (newsletters, magazines, handbooks), through national contests and through attractive meetings.

Fund-raising. The activities of the national office can require substantial funds if the association is very large, and even a smaller organization may have difficulty in finding sufficient support. Membership promotion may require the preparing, printing and mailing of letters and descriptive material. A national newsletter involves preparing the editorial material, printing and mailing. A national meeting requires rooms for sessions, space for exhibits, transportation for field trips and a printed programme. All these tasks involve costs which can be considerable.

Leadership

As with any association, the leadership at both the national and the local level is critical to the success or otherwise of the society:

National level. To run a national programme requires a combination of administrative ability, knowledge of out-of-school scientific activities, some familiarity with science and an ability to raise funds. It is not always easy to find this kind of leader, and yet without him, the programme will suffer.

Local level. The success of the association's programme depends to a substantial degree upon finding and recruiting competent adult sponsors at the local level. Without good sponsors, the local clubs will not be successful and membership will drop. As most sponsors are teachers, the potential sponsors can be reached through schools by means of letters and descriptive material, through articles or advertising in teachers' journals and through meetings of teachers. Reaching, recruiting and holding these teachers are essential elements in the success of any junior association.

Value

The principal value of a junior science association lies in the fact that it is an organization that promotes out-of-school scientific activities on a national basis.

To keep out-of-school scientific activities going requires continual effort to help existing clubs. Just because a club exists does not necessarily mean that it is doing much, or that what it is doing is very good. Most clubs, of whatever quality, would welcome ideas and assistance, and these ideas and assistance might possibly be what keeps a club in existence. Starting (or restarting) a club does not often occur without encouragement and help from the outside. It cannot be assumed that a club will start spontaneously. Somebody must not only suggest forming a club, but go on repeating the suggestion until something actually happens. Moreover, once the club is formed, it will have a much better chance of surviving if it receives some support from the outside.

A second value of a junior science association is that it provides services which are generally not available to local clubs. There are four such services of particular importance:

1. *Publications.* Newsletters, magazines, handbooks and project books are usually difficult for local clubs to produce. They are extremely valuable, however, and serve to improve club programmes enormously.
2. *National meetings.* These are activities which a local club would never undertake and yet they provide a valuable service to both student members

and adult sponsors in exposing them to people and ideas from other parts of the country.

3. *Contests.* National contests provide a valuable service in giving more status to local and regional contests. They also give student members something towards which they may aspire beyond simply winning a local contest.
4. *Leadership training.* Associations may organize training sessions for adult sponsors, either to upgrade the abilities of those who already have some experience, or by training those who are new to the job. These training sessions may be national in scope, with participants from all over the country, or they may be organized to assist sponsors from a particular region or locality.

A third value of a junior science association is that it can function as a clearing-house for information on out-of-school scientific activities. Most clubs (or members or sponsors) do not have the opportunity to communicate with each other, and yet there are many instances where one club could benefit from the experience of another. An association can provide a clearing-house function to help its affiliated clubs to improve their existing activities or to learn about exciting new activities. Such information can be disseminated through publications, through sessions at meetings, or simply in response to a request by letter.

A fourth value of a junior science association is that it is a national entity. This has several advantages. It gives prestige to the local club that affiliates with it, and this helps the club in relation to other activities at school. In addition, students like the idea of belonging to a national organization, and so this helps with membership. Another advantage is that it can more easily maintain contacts with other national organizations, keeping members informed as to any national activities which are of interest. Finally, it provides a presence on the national scene which may be of help with anything from fund-raising to publicity. An example of the activities of a junior science association is given in Appendix II.

Youth science congresses

A congress for young scientists is an organized series of meetings and discussions on pre-selected scientific topics in which the participants are young people. The meeting may extend over a period varying from one day to several weeks. Such congresses may also be associated with a science camp in an educational institution or with a science fair or exhibition. Science congresses can be arranged at a local or national level, or indeed at an international level.

There are several types of congress, and their ingredients will vary. They may, for example, include lectures and group discussions on specific scientific topics. Research papers may be presented, describing projects carried out by the young scientists, under supervision, during the period leading up to the congress. They may emphasize novelty, that is, they may be meetings concerned with films, exhibitions, lectures and/or seminars designed to popularize certain aspects of science for young people. Another type tries to create an awareness among young people of the relevance of science and technology to development in a local or national context.

Congresses of the first type are very similar in pattern and organization to those organized by learned scientific societies, both nationally and internationally. The presentation of original research carried out by the students themselves reaches the level of validation before an informed scientific audience that is the hallmark of true science. If such papers are subsequently published in a journal or in the proceedings of the congress, this is even more like real science and the work of research scientists, and provides enormous stimulation and motivation for the youngsters concerned.

The more usual congress, which consists of lectures, discussions, workshop and visits, can be illustrated by the programme for the 1984 International Youth Science Fortnight held in London (United Kingdom). There were lectures or lecture-demonstrations on topics such as 'Explosives', 'Cancer medicine', 'Processing pictures with computers', 'Forecasting the world's weather', 'The physics of sport', 'The chemistry of new energy sources' and 'Achievements with anti-matter'. There were workshops on 'Nuclear and renewable energy research in Britain', 'Recent concepts in the treatment of sport', and 'Traditional medicine – is it worth studying?'. There was also a debate on 'The nuclear question' and a question time with members of parliament. Visits were arranged to a large number of universities and government departments concerned with science and research as well as to major industrial laboratories.

A more varied type of congress is illustrated by the Singapore Youth Science Fortnight, an annual event, first organized in 1978. Around 100,000 students now participate directly or indirectly in its various activities. Since 1982 the scope of the Fortnight has been extended to include neighbouring countries. It is jointly organized by the Singapore Science Centre and the Science Teachers' Association of Singapore.

The objectives of the Singapore Youth Science Fortnight are: to give youth a deeper insight into science and technology; to allow young scientists to discuss scientific problems and the implications of science on society both among themselves and with the senior members of the scientific community; and to allow educators of youth to exchange views and experiences in science education.

The following are some of the innovative activities of the Fortnight:

The Science Fair is to encourage students to undertake independent research-type projects on various aspects of science such as biology, chemistry, mathematics, physics and computer science. In doing so, the students will experience the joys and sorrows of a scientific life. To enter the Science Fair, each entrant is required to write a report describing his project and its findings. The student will then be requested to display the equipment and materials used in the project together with brief notes describing his project at the Fair.

Science Circus consists of science games and demonstrations. They all illustrate simple and interesting scientific theories which are more often than not taken for granted. The Circus allows both parents and children to enjoy science in an informal atmosphere.

For photography enthusiasts, the Science Photo Competition provides an opportunity to develop innovative ideas and skills by capturing aspects of science and technology in pictures. All entries must illustrate scientific phenomena, concepts or principles.

The Science Fiction Writing Competition provides an opportunity for students to express their thoughts and emotions in a novel setting.

The Science Fiction Film Festival allows students to experience the interface between science and art and stimulates their imagination.

The Science Olympiad, unlike other contests, is not a test of memory but, rather, a test of the students' ability to solve problems in an analytical way. It is a competition involving speed, knowledge and accuracy.

The Four-day Science Camp allows pre-university students to appreciate nature and the need for its conservation. The fields of study include the flora of reclaimed land, the ferns of the Bukit Timah Nature Reserve, ecology of a reservoir, ecology of a coral reef, and so on.

Organization

The arrangements for a congress are similar to those for a science camp (see Chapter 5, pages 75 et seq.). In addition, however, it is necessary to secure the services of distinguished scientists as speakers or leaders of discussions, and the support of organizations and institutions for the various visits. All these have financial implications for which funds must be secured either by charging registration fees or from grants or both.

For a congress in which the participants will be presenting the results of their research work or project work, the organization might follow the stages below:

Preliminary steps

Formation of an Organizing Committee. The formation of this Committee should be the first step taken by the person or institution promoting a junior scientific convention. The tasks to be carried out by the Committee make it advisable that it be composed of science teachers... and university... scientific specialists who may have taken part in previous Conventions and are interested in educational processes. One of the latter might be assigned the duty of Scientific Adviser to the Committee.

It will be the responsibility of the Committee to draw up the rules, and plan the implementation of the Convention, distribute informative material and appoint an Advisory Selection Committee to examine the studies submitted. The Organizing Committee should also of necessity concern itself with the basic administrative aspects typical of all scientific gatherings.

Promotion and divulgation. It is essential that the organizers publish a brochure containing a description of and the rules for the planned event, instructions to those wishing to take part and, if possible, summaries of past studies.

It should be borne in mind that studies for submission to a Convention and the drawing up of the corresponding reports will call for a preparatory period of six to twelve months. Opportune and appropriate promotion may ensure the satisfactory quality of the studies submitted.

Advisory Selection Committee. The Organizing Committee should invite a group of professors and scientific experts to act on the Selection Committee. The members of the latter should be specialists in the subjects submitted to the Organizing Committee and will be required to advise in connection with the participants who should be invited to present them.

It is advisable that the members of the Selection Committee draw up comments on the studies in question in order to facilitate their discussion at the Convention. They may also nominate those who will be taking part as moderators and invite specialists to attend the event.

Planning of other activities. It is advisable that during the Convention, which may last two or three days, other activities be organized such as conferences, lectures, excursions, cultural activities, etc., in order to provide further opportunities for personal contact between the young participants and professors, scientific experts and other young persons and thereby enrich their scientific, vocational and cultural experience. It is advisable for this reason that these conventions be carried out at places capable of accommodating all participants and organizers. In this manner it will be possible to arrange for late evening lectures or meetings on topics associated with education, science and culture.

Convention procedure

Moderators. They will preside over and direct each of the sessions and control the length of time of each presentation as well as that devoted to questions. It is important that the moderators be acquainted with the subject(s) to be dealt with at the sessions and that they belong to the group involved in deciding on the selection of presentations. After each presentation, the moderator will invite the audience to put forward questions and comments and will ensure that discussions proceed in an orderly manner.

Presentation of work. It may tentatively be decided that each participant be allowed ten minutes to explain his study, including the showing of any audiovisual material, followed by five minutes for questions and a further five for final discussion. The author will explain his study without reading it. (The organizers should see to the provision of sound amplification equipment and other audiovisual media.) Interruption by the audience should not be permitted and questions may be asked after the presentation.

The speaker will adjust his presentation to the time allotted, taking care to confine his comments to the more significant aspects and conclusions of his work. He will be able to complete or add to his explanations during the subsequent discussion.

The moderator may exceptionally allow an extension to the allotted time limit to enable a significant aspect to be dealt with in greater detail.

The moderator will take note of the speaker's performance and sum up the presentation before inviting the next exponent to come forward.

Discussion of work presented. After completion of the time allotted for presentation, the moderator will give members of the audience the opportunity of expressing their thoughts on the matter. He may either call on the exponent to expand his answers to questions from the audience, reply to a question himself or suggest that it be dealt with more fully outside the meeting. The moderator should not allow any questions or comments not relevant to the topic under discussion. Other scientific specialists or teachers present may intervene...

Moderator's comments. After completion of the time allotted for presentation of the selected studies, the moderator and his collaborators will comment in turn on the reports and formulate a constructive criticism concerning the presentation and points discussed (OREALC, 1984, pp. 36-8).

Reference

OREALC. 1984. *Manual for the Promotion of Scientific and Technological Activities for Young People*. Santiago (Chile), Unesco Regional Office for Education in Latin America and the Caribbean (OREALC).

FIG. 7. Juvenile Science Convention.
Source: OREALC, 1984, p. 33.

3. Science fairs, research and project work

Science fairs

A science fair is an exhibition of projects carried out by students. Most fairs are competitive, with awards being granted on the basis of the scientific or technical merit of the projects. The topics covered may be in the fields of science (physics, chemistry, biology, geology, etc.), mathematics, engineering and technology, medicine and health, and agriculture.

Science fairs range in scope from school fairs, which may involve one class or school, to city-wide fairs with many schools participating, to regional fairs which may involve a large geographic area, to national fairs in which students are selected from schools throughout an entire country, to international fairs with students from two or more countries.

Objectives

The overall objectives of science fairs are to stimulate in young people an interest in science and engineering, to provide an educational experience through participation in project work and through attending a fair, and to give public recognition to students for the work they have done.

Fairs meet the needs of individual students by: involving them in activities that require 'doing' science and engineering rather than merely hearing or reading about them; encouraging individual responsibility for learning; motivating through active rather than passive learning; enabling the student to study a subject in greater depth than is possible in the regular curriculum; enabling the students to receive personal recognition for their achievements; providing a learning experience through the preparation of the exhibit and the presentation of oral reports and answering questions at the fair; and utilizing the students' time in a constructive and useful way.

Fairs also meet the needs of teachers and the public by: stimulating an interest in science and related fields; providing an opportunity for displaying the intellectual and technical accomplishments of young people; encouraging members of the community to meet young people; providing the public with an opportunity to evaluate schools, in that the quality of the projects reflects the quality of the schools; and providing an opportunity for teachers to work with students as individuals.

Projects

A project involves a student in identifying a problem or question, studying it independently by gathering information and data, and arriving at conclusions based on the said information and data. Students should be encouraged to work on their projects more or less independently and in their own time.

The problems or questions studied by students can be drawn from every field of science, engineering, medicine, agriculture or mathematics. They may require theoretical, field or laboratory studies. They may involve work with nothing more than a paper and pencil, or they may require extensive laboratory equipment and facilities.

Project work has, as a characteristic, the active participation of the student. Projects tend to take a much longer period of time than that required for homework or examinations. They tend to be individual, in that no project is exactly like another. Where possible, project topics should reflect the interests and abilities of the particular student involved.

Projects vary a great deal, depending in particular upon the age and abilities of the particular student involved. They generally fall into one of the following categories:

A presentation of material on some topic, where the sources of the material are books, pamphlets, newspapers, museum displays or visits to factories or farms. Here the emphasis is on the gathering and summarizing of information already in existence, such as a display on the life cycle of an insect or the anatomy of the human being. This is the simplest form of project work.

A working model which shows that the student has some understanding of the scientific or engineering principles involved rather than just building something from a kit. Such a model might demonstrate some scientific principle, or it might be an invention solving a local problem.

A report based on first-hand investigation by the student, where the student himself has made some contribution in gathering and analysing the data rather than simply taking it from a book or other secondary source. Two examples are: a butterfly collection, indicating the kind of habitat in which the butterflies were caught, and geographic location; and a chart recording the amount of rainfall in a specific locality as measured by the student over a period of time.

An attempt to solve a problem by conducting an experiment such as comparing the effectiveness of two kinds of feed on the egg-laying of hens. Here some attempt would be made to control the variables.

Students should be encouraged to select a project in an area in which they are particularly interested, so that it is something to which they can give their time enthusiastically. In some cases, the project may be based on an idea which came to the student from reading. In other cases, it may arise out of a hobby, from seeing what other students have done at science fairs, or from a visit to a farm, factory, museum or laboratory. In still other cases it may arise from a question which has been raised in the classroom.

Science fair projects can be carried out by individual students or by groups of students. Both approaches have advantages and disadvantages.

Individual projects provide a wider range of choice in the selection of topics, since the student can select what he wants without taking into account the interests of others. Individual projects also tell more about a student in terms of his knowledge of the subject, creativity and initiative: it is easier to evaluate an individual student's contribution to his own project than to a group project. Lastly, individual projects provide much greater satisfaction for many students in that the project is theirs alone and not shared with others.

On the other hand, group projects often make it easier for a student to gain experience of project work, in that he can do part of the project without being responsible for the entire activity. Thus a group project might involve students who would not otherwise become involved in project work. Group projects teach co-operation in complex tasks and team participation, something which is increasingly important in science and in other areas of life today. In addition, group projects appeal to the 'team spirit' in some students, motivating them in a way similar to team activities in sports.

Preparing the exhibit

The exhibit should be organized so that it will be meaningful to a range of viewers, including science fair judges, teachers, students and members of the public. The following outline may be used, but it is not the only one possible, and unusual aspects of a project could justify substantial changes:

Titles: these should be brief; a sub-title may be used to explain a main title which is technical.

Summary: this provides a short description of the project and explains its significance.

Hypotheses and conclusions: these should be listed briefly and clearly, leaving those who are interested to obtain details from the student or from a report or notebook.

Method and scope of investigation: only the most important points should be listed.

Observations and data: show only key data, and let the notebook or report provide additional details.

Photographs and illustrations: use these where they will help with the presentation, or in terms of interest or understanding.

Equipment and specimens: use these to provide a better idea of what was done, or to add to interest.

Notebook and reports: use these, if available, to provide additional details for interested viewers.

Abstract: this is a single page (250 words) which can be reproduced and handed out to interested persons.

At a science fair, there is usually some form of space limitation for the exhibits, and the student should be sure to find out what the requirements are before designing his display. Since the student will probably have more to present than space permits, an important part of the planning is deciding what to show and what not to show.

There is one important point to bear in mind when designing an exhibit: it has to be moved into the exhibit space, set up for the fair and then dismantled to take out again. Thus it should be designed for ease of movement. An alternative is to bring exhibit materials to the science fair and construct the exhibit on the spot.

The project adviser

The project adviser is a key person in a science fair, and can be an important influence on the student and the quality of his work. The project adviser directs, guides and consults with the student at all stages of project work. This adviser is usually a teacher, but he may also be a scientist, engineer, doctor, technician or parent.

The adviser should make his role that of guide, and leave as many decisions as possible to the student. Thus the selection of the topic should remain with the student and, while the adviser may suggest topics and discuss their possible advantages and disadvantages, he should not be involved in the actual selection.

Similarly, the adviser should require a plan of work from the student, and criticize it and suggest changes. But the plan itself should be as much as possible the work of the student. During the actual carrying out of the project, it may be difficult for the adviser to stand aloof, especially if the student is seen to be making mistakes. But it should be remembered that the student will learn the most by doing the work himself, and the adviser's role should be limited to giving advice. On the other hand, the adviser should not hesitate to assist the student when it is clear that he cannot progress any further without help.

Organizing a science fair

Science fairs can be sponsored and organized by any interested organization or group of adults, ranging from the Ministry of Education of a country to a group of teachers in a single school. Thus fairs can be organized through a decision of the Ministry of Education, and can move sequentially from a national fair to state fairs, city fairs and, finally, school fairs. Alternatively, it is possible to begin with one fair in a single school, moving to other schools and then to cities and states before arriving at the organization of a national fair.

A science fair movement with national sponsorship (Ministry of Education, national scientific society) usually begins as the result of a high-level decision to have such a programme. Once such a decision has been made, the major steps in the development of the programme are as follows:

1. A national science fair committee is set up, composed of prominent scientists, engineers, medical doctors, educators and others interested in the activity.
2. The committee selects a national science fair director.
3. The committee and director decide on a date and location for the national fair. For this, it is important to co-ordinate with the educational authorities so as not to compete with important dates in the school calendar, such as examinations, or with school holidays.
4. The national fair director, in collaboration with the national committee, is responsible for organizing and running the national fair – determining rules, selecting and supervising judges, organizing the programme for the fair, and so on.
5. The national fair director is responsible for drawing up a budget for the fair and for raising the funds, if the government does not provide them.
6. The national fair director selects state science fair directors, who will co-ordinate with educational authorities, set dates and select locations for state fairs.
7. The state directors will in turn be responsible for city or regional fairs in their states, and for these fairs in turn resulting in school fairs.

In a situation where there is no national science fair programme, fairs usually begin with interested teachers in a single school who organize a fair; the movement then spreads to other schools and localities.

In the case of non-governmental sponsorship, sponsors may include schools, school systems, colleges and universities, businesses, civic clubs or newspapers, or a combination of some or all of these. The degree of participation of sponsoring organizations can vary widely, from simply letting their names be used to that of financing and staffing the fair. Individuals such as teachers, scientists, engineers, medical doctors and parents may also get together to sponsor a fair. School science clubs may also act as sponsors.

Once the initial interest is there, the developmental sequence is roughly as follows: (a) preliminary conversations between interested persons; (b) decision to organize a fair and the establishment of some sort of committee with the objectives of organizing and conducting the fair; (c) meeting with school authorities to discuss plans and to obtain support and co-operation; (d) organizing more fully, assigning responsibilities to various persons and recruiting more participants if necessary; (e) deciding on the fair's date and location; (f) getting teachers interested; (g) getting students interested and started on projects; (h) informing the public to assure a good attendance; (i) working out a budget; (j) beginning fund-raising.

A checklist of these stages, with a timetable, is given in more detail in Appendix III.

Awards

If the fair is to be competitive, then some sort of recognition or award should be provided for the winners. There are many different types of award, including the following: the issue of certificates or medals to all participants in the fair; certificates of first, second, third and fourth place; coloured ribbons for various levels of winner; cash awards; books on scientific and technological subjects; scientific equipment; scholarships to college; trips to points of scientific interest; guided tours to laboratories, museums, and so on; summer jobs; magazine subscriptions; plaques or trophies; the opportunity to participate in a larger fair, competing against students from other fairs; and a grade based on the quality of the project, which would be used in the student's final course evaluation.

Judging

Science fair judges have two principal functions. First, they evaluate all students and their projects, so that the best can be selected for awards. Second, they talk to all students, regardless of whether they will be winners or not, and try to motivate and interest them in science and related fields. This second function is in some ways more important than the first, for the discussion of the project with the judges can greatly influence the student's outlook on science. In addition, judges become aware of the students' interests and friendships. Future consultation, summer job opportunities, or college scholarships may also result.

Judging is the single most important activity in the fair, and the most valuable and interesting experience for the students. For this reason, it is important to invite the best possible people to be judges, to have a sufficient number of judges, to brief the judges carefully on their duties, to ensure that every student is spoken to by the judges, to select judges who have some interest in young people and to select judges who regard a science fair as an educational opportunity.

Depending upon the fair's objectives and the individuals available, judges can be selected from the following groups: teachers (preferably science teachers); college and university professors in science, engineering, etc.; members of the medical profession; members of scientific and engineering societies; technical experts; and research scientists.

Judges are almost always unpaid volunteers; it is therefore important to start looking for them several months ahead of time, in order to secure an adequate number. This in turn depends upon the number and sophistication of the exhibits entered in the fair. A minimum of three judges for a small fair is recommended, as is a minimum of one judge for every three student participants. In fact, the more judges the better, as the fair is an educational experience as well as a contest. For larger fairs, the exhibits may be divided into categories (physics, chemistry, etc.); if this is the case, the judges should also be divided into corresponding teams.

The criteria for judging the students and their projects are usually the following: creative ability, scientific thought/engineering goals, thoroughness, skill, clarity of presentation, and possible applications and their relevance to national goals.

Finance

The amount of financial support needed by a fair will depend upon the type of fair (school, local, regional, national), the size of the fair, the number and type of awards and various other possible variables. An estimate of what the fair will cost should be drawn up well in advance. This may be difficult for the first fair, but thereafter drawing up the budget should be relatively easy. A typical budget for a medium-sized fair might include the following items (note that some could be contributed whereas others will have to be paid for): exhibition hall, tables to hold exhibits, fireproof drapes for tables, signs, meals and lodging for students and accompanying teachers from out of town, awards (cash awards, ribbons, trophies, etc.), printed programme and special events (awards dinner, tours).

All regions have a number of potential sources for raising funds, quite apart from direct support provided by a government department. These sources include: selling items by students or parents, staging a benefit performance (talent night, plays), community activities (dinners, sports, etc.), business organizations, industry, newspapers, civic organizations, scientific, engineering and medical societies, parent teacher associations, science clubs and programme sales.

Questions of policy

Compulsory versus voluntary participation. The question of participation has two aspects: whether the students should be required to do a science project and whether they should be required to participate in a science fair. Most schools do not require students to do science projects. There is a growing body of opinion that supports required projects, however, on the grounds that they provide a valuable learning experience. In addition, many teachers feel that projects may stimulate the students' interest in science. If a project is required, its assessment may be taken into consideration when determining the final grade for the year in the course.

Those who do not favour required projects generally give some of the reasons outlined below. Many students are not capable of good project work, and for such students, a project is a waste of time. Projects require materials and equipment which many schools or students do not possess; thus it is difficult to do anything interesting or valuable. If projects are compulsory, this imposes a substantial additional supervisory burden on usually overworked teachers.

Not all schools require students to participate in science fairs. Those schools which do require participation regard it as a valuable learning experience for the student, regardless of how well he does. Those in which participation is voluntary, on the other hand, generally believe that only interested and motivated students should participate, and that compulsory participation is counterproductive in that it lowers the overall quality of the fair.

Competitive versus non-competitive fairs. In most countries, science fairs are competitive. The majority of international fairs, on the other hand, are non-competitive. The reasons for making science fairs competitive include the following: winning provides recognition and stimulation; competition provides additional interest for parents and the general public; students enjoy competition, and it makes them more interested in science fairs; and competitive selection provides the basis for identifying students with abilities other than those which are purely academic.

Some of the reasons for making science fairs non-competitive are as follows: those students who do not win are disappointed, and their interest in science decreases; competition can become excessive, with too much pressure put on the students; teachers or parents who want a student to win may do much of the project work themselves, rather than letting the student do it; and participation is reduced on the part of the less able, who see no possibility of winning.

Research and project work

Research undertaken by students consists of activities similar to those in which a professional scientist or engineer is engaged. In most cases, however, the research is at a much lower level of complexity and sophistication.

For a student, research involves identifying a problem or question, working on it independently to gather information and data, analysing the data and arriving at conclusions. Actual research varies from discipline to discipline. It may involve: field work, as in geology; theoretical work, as in mathematics; laboratory work, as in chemistry; or a combination, such as occurs in the chemical analysis of geological specimens gathered in the field.

Characteristics of research

1. Research usually takes a much longer time than is required for school homework or routine laboratory work. Some projects can be completed in a relatively short period of time; others may take months or even years. The time usually increases with the quality and sophistication of the project.
2. Research is characterized by the active participation of the student during the project. Such participation may range from the construction and use of laboratory instruments, to observations of animals in their natural habitat, to writing computer programs.
3. Research projects are individual; no one project is exactly like another, nor should it be. Even in trying to solve the same problem, the approach may be different or the results may be different.
4. Research problems are real problems, involving real questions as opposed to the contrived ones set for homework or examinations.
5. Research permits a student the luxury of failure without penalty. In real research, no scientist ever arrives at a conclusion without considerable work, and more experiments fail than succeed.
6. At the more sophisticated levels, research involves dealing with the unknown, where decisions must be made using data that are not as clear-cut as those used in textbooks and demonstration lectures.
7. The individual complexity of research makes it more difficult to assess than an examination. In the case of more sophisticated research, it may require a scientist who is familiar with the field to carry out a proper evaluation.

Organizing research work

Because of the highly individual nature of research, there is no single way in which procedure might be structured. Instead, there are a number of different approaches which are differentiated by the type of sponsor.

Individual. Some research takes place simply because the student wishes to do it, and there is no adult sponsorship at all.

Parental sponsorship. Other research might be undertaken under the sponsorship of a student's parents, who see it as a valuable activity.

School sponsorship. Research may be encouraged as an extra-curricular activity by the school, perhaps leading to participation in a science fair. It may be part of a school science club activity which takes place after school hours.

Research organization. Research may be carried out by individual scientists who have one or more students working in their laboratories.

Location of project work

Students who are engaged in research projects do their work in a wide variety of settings and under the sponsorship of a wide variety of individuals and organizations. The following are some examples:

Laboratory research

Home. Some students do their research work at home. While a few students may have sophisticated apparatus or other equipment, most of the work is done with a minimum of equipment, facilities and background information, and often with little or no knowledgeable supervision by adults. In most cases, these projects tend to be relatively unsophisticated and usually comprise observation or collecting.

School. Many other students work at school, usually with more guidance, equipment and facilities, and with technical literature available. This work is often done informally after school, or as a part of a scientific research club.

Professional scientific laboratories. The most sophisticated research is generally done in conjunction with professional research scientists. This may be through informal arrangements, where an interested scientist takes on one or more students, or there may be a more formal programme, where students are brought in every day to work in laboratories. The advantage of this kind of work for the students is, first of all, the constant contact with working scientists and their graduate students. In addition, working in a professional laboratory gives students access to equipment that most schools do not possess.

Field research

Home or neighbourhood. This is the field equivalent of the home laboratory. This kind of research is usually relatively unsophisticated, involving collecting, gardening or other relatively simple activities.

Farm. Where access to farms is available, students may be able to do more sophisticated and complicated kinds of projects, such as controlled experiments to test different kinds of feeds on the egg-laying of hens.

Field trips. These involve going some distance from home or school, perhaps to a nature reserve, mine, lake or archaeological dig. Such trips might involve collecting, either at an elementary or sophisticated level, or observation.

Expeditions. The term ’expedition’ is used to denote a field trip that takes the student away from home, usually to some distance, for an extended period of time. This is the field equivalent of working in a scientific laboratory in that the expedition often has a scientific purpose and the student works as a part of a professional team.

Presenting the results of research or project work

An important aspect of research is recording its results for, if research is to be of any use, it must be disclosed to others, either orally or in writing. For scientists, the most important means of communication is the scientific paper published in a journal, followed by the presentation of papers at scientific meetings (see Chapter 2).

For a student, part of the value of research lies in the experience acquired in reporting the research through writing a paper, making an oral presentation at a club or junior academy meeting, or preparing an exhibit for a science fair and answering the judges’ questions.

The scientific paper

A research report has certain characteristics which distinguish it from most writing in prose. Its purpose is to communicate precisely, and its language is selected for readers who are familiar with the particular field of science. There is an economy of words in science writing which allows it to go directly to the point, define the background, the problem and the procedures, give the necessary data and state the resulting observations and conclusions. It does not include personal feelings or literary clichés. A scientific paper, in other words, has a sort of mechanical purposefulness and a cold impersonality which confines itself strictly to reporting research information. A research paper usually follows a format such as described below.

Title page. On this are set out the title of the paper, the name and address of the author, and the date. The title should be brief; if accuracy requires more than a few words, a longer sub-title may be added.

Abstract. This is a brief condensation of the entire report. It summarizes the objects, stating what was done and the conclusions reached. The purpose is to give an idea of the contents and help the reader to decide whether to read the paper in detail. The abstract should be written after the main body of the paper has been completed.

Methods. This part describes in detail the methods, experiments and controls, including difficulties and remedies, used in the research.

Observations and data. Here the observations made are described, and details are given of the evidence developed for each main conclusion reached. Opposing theories are discussed, and possible explanations offered. This part may include a comparison of work done by others.

Conclusions. This section analyses the results of the investigations and includes questions, possible applications or recommendations for future research.

Tables and figures. These give supplementary information, including graphs, tables, diagrams, charts, photographs and drawings.

Bibliography. This lists books, journals and other reference materials actually used in the project.

Oral presentation

An oral presentation differs from a written presentation in a number of ways. It is generally shorter, and may employ audio-visual aids such as a blackboard, projector and slides, charts or film.

The oral presentation should be organized like a written paper, but, if the speaker is experienced, it can be more informal. It should always be planned to conclude a little short of the required time, so as to allow for questions and discussion. A good rate of reading is about 100 words per minute, so a ten-minute talk would use about 1,000 words. A speaker should prepare a draft of his talk, and then read it aloud once or twice to check its timing.

Visual aids can make a presentation more interesting, but they should be used well or not at all. Their main advantage is that they can show some things (experimental equipment, graphic relationships, etc.) that words cannot describe as vividly. If visuals are to be used, some indication should be made in the script so that the speaker will remember when a particular visual should be used. Visuals tend to make a talk last longer, so in timing the presentation, references to the visuals should be included.

The science fair exhibit

The exhibit should be organized and designed so that it will be meaningful to a range of viewers, including the judges of the science fair, teachers, students and members of the public.

The following outline can be used, but it is not the only one possible, and unusual aspects of a project could justify substantial changes.

Titles should be brief. A sub-title may be used to explain a technical main title.

The summary provides a short description of the project and its significance. Hypotheses and conclusions should be brief and clear, leaving those interested to obtain details from the student, or from a report or notebook.

The method and scope of investigation should list only the most important points.

Observations and data should be key data only. The notebook or report can provide additional details.

Photographs and illustrations should be used where they will help with the presentation, or provide interest or understanding.

Equipment and specimens can provide a better idea of what was done, and add interest.

The notebook and reports, if available, provide additional details for the interested visitor.

An abstract can be reproduced on a single page and handed out to interested visitors.

During the fair, the student explains the details of his project to the judges, to other students, to teachers and to the general public. This explanation, carefully prepared and rehearsed, should last about five minutes for science fair judges and two or three minutes for others. It should follow the sequence in which the exhibit presents its information. After the presentation, the student should be prepared to answer questions.

Ideas for projects

Students should be encouraged to select a project in an area in which they are particularly interested, so that it is something to which they can give their time enthusiastically. In some cases, the project may be based on an idea which came to the student from reading. In other cases, it may arise out of a hobby, from seeing what other students have done at science fairs, or from a visit to a farm, factory, museum or laboratory. In yet other cases, it may arise from a question which was raised in the classroom.

Students often wish to undertake projects, but cannot think of a subject.

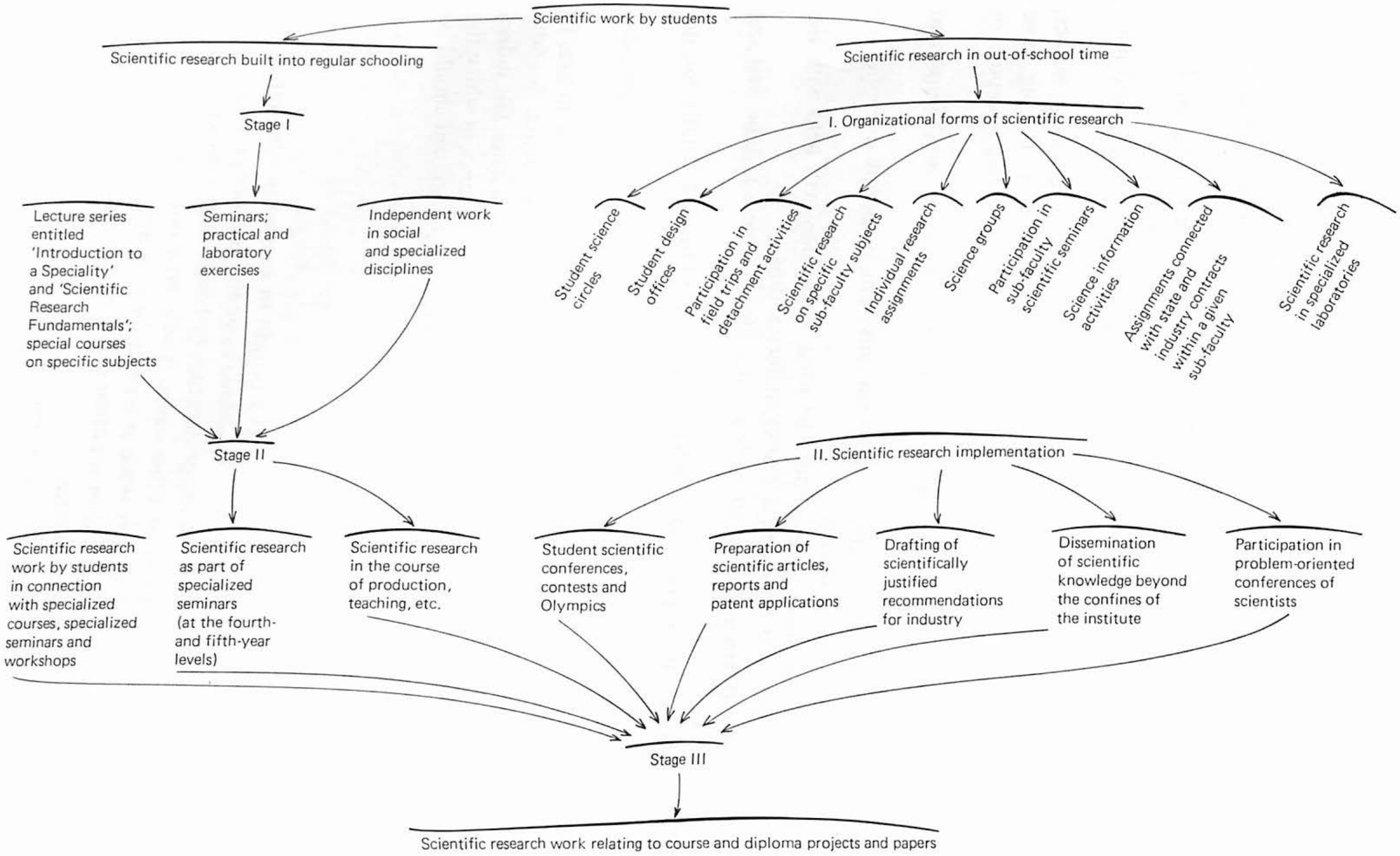

Scientific work by students
Scientific research built into regular schooling
Scientific research in out-of-school time
Stage I
I. Organizational forms of scientific research
Lecture series entitled 'Introduction to a Speciality' and 'Scientific Research Fundamentals'; special courses on specific subjects
Seminars; practical and laboratory exercises
Independent work in social and specialized disciplines
Student science circles
Student design offices
Participation in field trips and detachment activities
Scientific research on specific sub-faculty subjects
Individual research assignments
Science groups
Participation in sub-faculty scientific seminars
Science information activities
Assignments connected with state and industry contracts within a given sub-faculty
Scientific research in specialized laboratories
Stage II
II. Scientific research implementation
Scientific research work by students in connection with specialized courses, specialized seminars and workshops
Scientific research as part of specialized seminars (at the fourth- and fifth-year levels)
Scientific research in the course of production, teaching, etc.
Student scientific conferences, contests and Olympics
Preparation of scientific articles, reports and patent applications
Drafting of scientifically justified recommendations for industry
Dissemination of scientific knowledge beyond the confines of the institute
Participation in problem-oriented conferences of scientists
Stage III
Scientific research work relating to course and diploma projects and papers

FIG. 8. Ways and means of conducting scientific work by students.

Sources for project ideas can come from many places, including books or magazines collected by the teacher or school; an ideas list compiled by the teacher, listing projects which have occurred to him in the past; and lists of projects undertaken by other students at science fairs in the city, region, country or group of countries.

Some examples of research projects from a variety of countries are given in Appendix IV. A diagrammatic representation of the ways and means of conducting scientific work by students is shown in Figure 8.

4. Olympiads, contests and talent searches

Science olympiads

An olympiad is a contest between individuals and teams in which the participants' knowledge, capabilities, skills and attitudes are assessed in particular scientific and technological fields. Special emphasis is usually placed on the ability of participants to resolve problems. The contest may have many different events, each lasting for a few minutes to an hour or more, with the entire contest lasting as long as a day. There is no limit to the variety of events. These may range from practical problem-solving exercises to written quizzes. The only limitation is the ingenuity of the organizers and sponsors.

Science olympiads have the following purposes:

1. They aim to stress the 'fun' side of science in order to involve as many students as possible. The activities are designed to use scientific knowledge and skills for enjoyment.
2. They aim for a wide participation on the part of students and do not limit this participation to the most academically able.
3. They permit students to demonstrate their scientific knowledge and skills to other students and to the public.
4. They encourage non-participating students and the public to become involved as the audience which cheers for the contestants.
5. They promote a school spirit by providing competition between schools.

There are a number of steps that must be taken when organizing a science olympiad. The importance and sequence of the steps may vary from situation to situation, but in general they include the following:

1. Estimate the potential interest by talking to students, teachers and school administrators.
2. Form a committee of three or more interested persons, and appoint a contest director.

3. Decide on the nature of the olympiad, and whether it will include quizzes, questions to be answered in writing, practical events or exhibitions.
4. Circulate information about the planned olympiad among the participating institutions.
5. Secure financial support.
6. Devise the necessary questions and tests, and arrange for the required facilities, including equipment and apparatus for the practical tests.
7. Select judges.

Science olympiads can be sponsored by almost any kind of organization with an interest in doing so. The most logical sponsorship is, of course, that of a school or school system. However, other organizations can be involved. They could include science clubs, museums, boy and girl scout organizations, industry and business, and local or national governmental organizations with offices in the community.

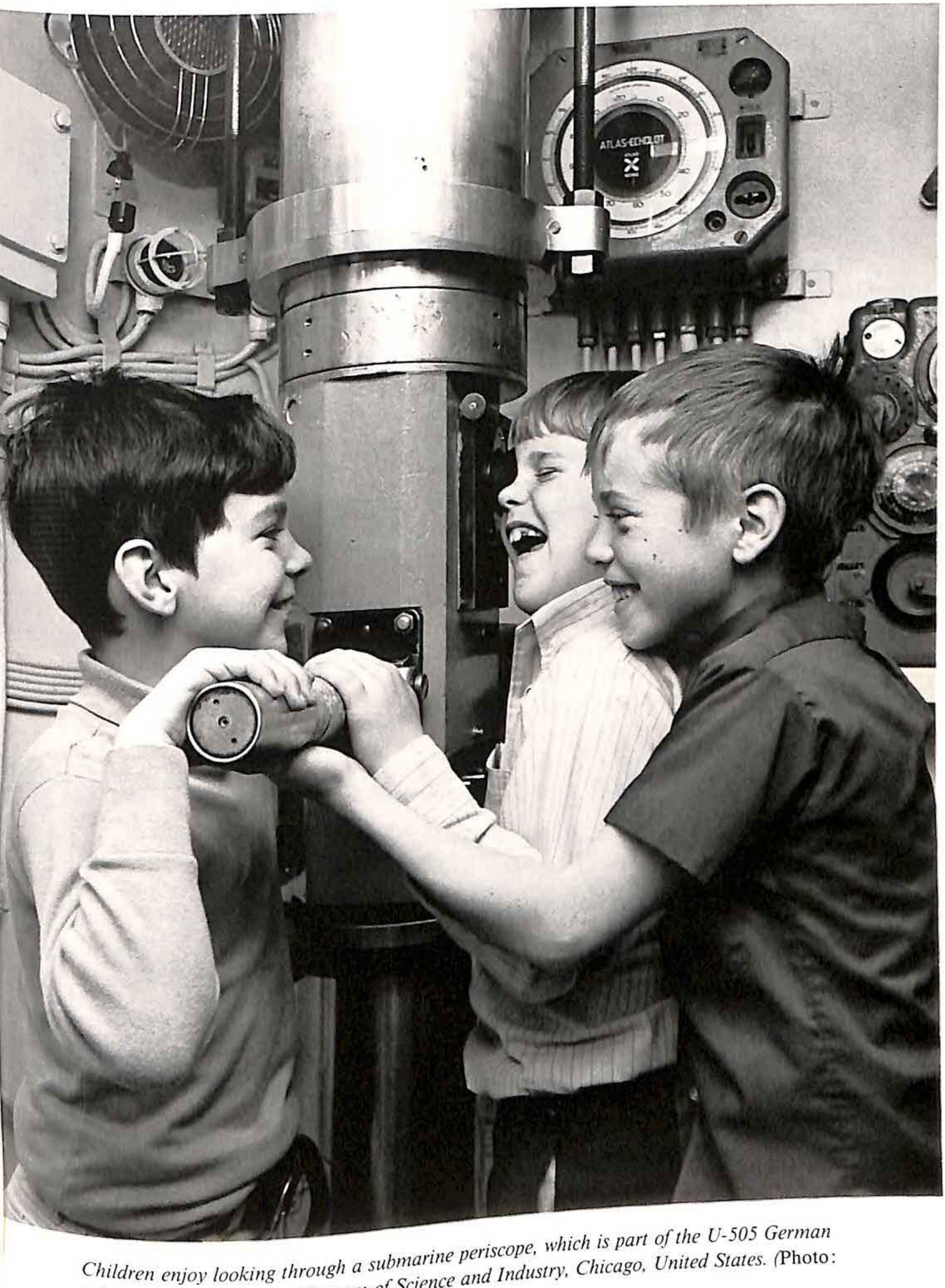
The prime value of science olympiads lies in their flexibility, which allows them to be adapted to the needs of the students at the time, as well as to the local situation. Contests can be large or small, simple or sophisticated, low-level or advanced and of short or long duration; they may cost almost nothing or involve substantial expense; and they may be carried out with or without the public.

Science olympiads also permit a wider range of participation on the part of the community, in that many of the events do not require persons with a substantial knowledge of science. This means that recruiting judges is easier; it also means reaching people in the community who would not normally help in out-of-school activities.

As in the case of science fairs, it is, as a general rule, advisable to establish different stages for the event. The organizing committee will determine the number of tests to be considered at each stage. It is probably best to include only one or two written tests in the initial stages and add one, or perhaps two, oral tests in the final stages.

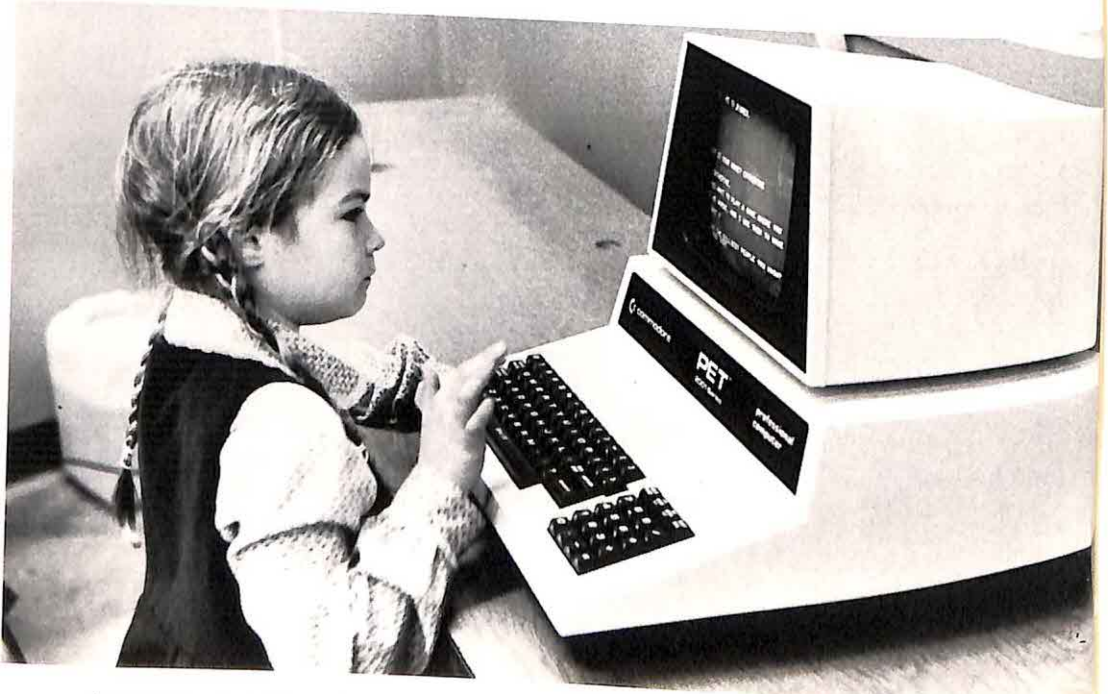
The committee should give particular attention to ensuring that the tests are of a type conducive to the achievement of the intended objectives. Their content and forms of presentation (oral and written) should be carefully considered. The tests should contain material consistent with the information which students receive in the course of their regular studies. It is possible, however, that some of the young people interested in participating may not be familiar with the material on which the tests are based. In order to minimize difficulties of this nature, it may be necessary to provide the participants with an appropriate, specially prepared bibliography.

The responses to the problems set should require the young participants to use intellectual capabilities such as understanding, synthesis, analysis and critical judgement. This will help in their studies. It is important, first of all, to ensure that the problems posed do not call merely for the direct application of a



*Children enjoy looking through a submarine periscope, which is part of the U-505 German submarine exhibit at the Museum of Science and Industry, Chicago, United States. (*Photo: *International Council of Museums.)*

*Lawrence Hall of Science, Berkeley, California, offers after-school classes and workshops for schools in chemistry for ages 5-15 years. Here students test different household liquids for acid/base properties. (*Photo: *Lawrence Hall of Science, University of California.)*



*Lawrence Hall of Science is one of the largest public-access micro-computer facilities in the United States. This young student is learning computer programming in a class entitled 'Creative Play with the Computer'. (*Photo: *Lawrence Hall of Science, University of California.)*

known technique or method of calculation. Second, it is necessary to see how the participants deal with problems whose solution requires the application of scientific concepts, observing the rigour and manner of formulating their deductions and the intelligent and correct application of the scientific methods, use of language, and so on. Situations may also be included which the young contender will have to treat as problems before embarking on their solution. In order to ensure impartiality in the evaluation of tests, it may be advisable to employ a system whereby the participants remain anonymous.

The duration of the tests should be established by those preparing them, with particular care taken over the length of time allotted to each item. In the case of written tests, they are best conducted in phases, with brief intermediary rest periods.

Science olympiads may be held with participants from a single class, one school (same grade levels only or different grade levels), several schools, a school system, a city or a country. There are also international olympiads (see below).

Although the emphasis in science olympiads is on fun and participation, it is still desirable to have awards. To begin with, participants should receive some form of recognition for taking part in the olympiad. This might be in the form of buttons, medals or certificates. Winners, of course, deserve more recognition. They could be given medals, certificates, small trophies, books or magazine subscriptions. In some cases, it may be desirable to have first, second and third place awards. A trophy is a good award for the overall winner or winning school. The trophy can be given permanently to the winner, or it can be competed for each year and passed on to the next winner. Finally, some form of awards ceremony should be organized to provide public recognition for the winners and participants. For a large contest, it may be possible to invite high-level individuals from the community, the education system or sponsoring organization to make the presentation.

International olympiads

The organization of national olympiads for science students has a long history in some countries, particularly in Eastern Europe. In Hungary, for example, the Physical and Mathematical Society organized olympiads for high school students as early as 1894. The first international science olympiad, with teams from several countries competing, was organized in Romania in 1959; it was a test of mathematical prowess.

Over the past twenty-five years, international olympiads have developed to include more countries from Europe and from North America and Latin America and to embrace all the sciences. At present, twenty countries participate in international physics olympiads, twenty-one in chemistry and thirty-four in mathematics (see Figure 9).

The official languages of the international science olympiads are English, French, Russian and German but all participants are allowed to write the solutions to the competition in their own language, if they so desire.

The international science olympiads facilitate contacts between young people from different political systems and different cultures. In this way, they contribute to international understanding.

Some examples of questions (and answers) from recent international olympiads in chemistry and physics are given in Appendix V.

Contests

Science contests are activities in which students strive to win by matching their knowledge and skills against each other in some way. Winners in contests may be those who have the highest scores in examinations, or those who have developed the best research projects.

Type of olympiad	Year	Place	Number of countries participating
Mathematics (1st)	1959	Romania	7 countries (Hungary, Bulgaria, Romania, Poland, Czechoslovakia, German Democratic Republic, USSR)
(25th)	1984	Czechoslovakia	34 countries
Chemistry (1st)	1968	Prague (Czechoslovakia)	3 countries (Czechoslovakia, Poland and Hungary)
(16th)	1984	Frankfurt (Federal Republic of Germany)	21 countries
Physics (1st)	1967	Warsaw (Poland)	5 countries (Bulgaria, Czechoslovakia, Hungary, Poland, Romania)
(15th)	1984	Stockholm (Sweden)	20 countries

FIG. 9. International science olympiads (first and latest).

Although classroom activities may be competitive in that students try to do better than each other, they are not contests in the sense used here. Contests are activities organized solely for the purpose of competing and, while they make valuable contributions to educational development, the straightforward accomplishment of academic objectives is only one of their benefits.

Contests are a popular form of out-of-school activity, appealing to students' competitive instincts in the same manner as sport, and providing public recognition for participation and winning. This public recognition on the part of the students' peers, teachers and parents, and of the community, is an important motivating factor and encourages the continuation and success of contests.

Contests in science and mathematics are held both because students like them and because they can contribute to educationally useful objectives. In general, contests have two objectives: to provide a showcase for knowledge and skills in science and to motivate students to increase their knowledge and skills in science through out-of-school work.

A key element is student participation. The contest must therefore be structured in such a way that it will appeal to students sufficiently to ensure not only that they will participate, but also that they will be motivated to improve their knowledge and skills in order to do better. This should apply not only to the less able students but also to the best. (See also 'Conducting a science talent search', pp. 70-71.)

Contests can vary widely, but, in general, they belong to one of three different types: question-and-answer, practical work, or essay. Contests may of course include two, or all three types, but they usually comprise question-and-answer and practical work.

Question-and-answer contests

These are contests where the winners are those with the largest number of correct answers to questions or problems. The questions are usually written, but in some cases may be given orally. The answers may derive from memory or be calculated (either with pencil and paper or from laboratory work). Responses are usually made in writing, but may be oral.

These contests have certain important characteristics. The questions are the same for all contestants. This may seem to be an obvious point, but most scientists engaged in scientific research are working on different questions. Only rarely does one find scientists working on exactly the same topic. When the objective is to compare student performance, however, it is easier when all the questions are the same. Again, it is self-evident that the students who take the test will have had no part in determining the problems. But this too is different from independent research, where the student formulates the problem that he works on. So, in contrast to real scientific activity, problems designed for a contest are, to a substantial extent, artificial. They exist only for the purposes of the contest. Other contrasts with 'real' science derive from the following: there is usually only one correct solution, the performance required is artificial and there is generally no interaction with the person evaluating the answers.

Practical contests

These are contests where the solutions to the problems are derived from physical manipulations through the use of equipment and instruments. The winners are selected on the basis of the best practical work, the best research project, the best equipment or the best computer program.

Essay contests

These are contests where the student is asked to write a paper on some specific topic or theme relating to science. There may be several topics to choose from and they tend to change from year to year. The winners are those whose essays are deemed 'best' by the judges, based on criteria established by the contest sponsors. Essay contests may be expository (for example, writing about the issues that relate to the sea) or they may be proposals for the solution of a scientific or engineering problem.

Variables

The types of contest may vary considerably. For example, the subject area may include all science topics, or specifically deal with physics, chemistry, biology, geology, engineering and so on. In addition, the geographical coverage may vary, with students coming from one classroom, one school, one city, one region, one country, or even a number of countries. Again, the number of participants may vary from a small number to thousands and the duration from a few minutes up to a number of days.

The judges may include parents and other non-scientists from the community, teachers or actual research scientists. The more sophisticated the contest, the greater the need for professional judges.

Recognition and awards

The recognition conferred and the awards given in contests are important elements in motivating students to participate. It should be remembered that while it is the student or students who receive the awards, the teachers and the schools are part of the recognition as well.

An important aspect of according recognition to students is the ceremony at which the award is presented. This can vary from a simple ceremony within a single classroom to an elaborate convocation at which important members of the community are present. Those attending the more elaborate ceremonies can include other students, teachers, parents, scientists, businessmen and government officials. The guest list will depend upon the importance of the contest and what the contest officials are trying to achieve. Greater parental interest and involvement might determine one kind of list while the desire to obtain national mass media coverage might determine another. The kind of ceremony and where it is held are also significant elements. A contest awards ceremony can be held in a classroom, a school assembly hall, a theatre, an auditorium, a basket-ball gymnasium or a hotel. It may involve a very simple presentation, or may include words of introduction to distinguished guests, speeches and elaborate presentation ceremonies.

Recognition of contest participants and winners in the media can range from posting names on a bulletin board, to a mention in the school newspaper, to coverage on a local radio station, to national newspaper and television coverage. The coverage depends on the importance (or perceived importance) of the contest, the ceremony itself and the importance of the award. If any of the regular media are to be involved, it may be necessary to write press releases, provide background material about the contest, schedule press conferences and arrange for interviews with the winners.

Participants may receive some appropriate recognition of their taking part but winners should receive something more tangible, such as a trophy which may be passed from winner to winner each year, with the student's name or the names of the team engraved on it. Further 'kudos' is conferred on winners if they are allowed to address a meeting of a scientific society, or if their papers are printed in a student journal. Other material awards can include scientific books, subscriptions to magazines, pocket calculators, computers or scientific equipment. Perhaps the most coveted awards are those which include a university place without having to take an examination, or a scholarship to cover all or part of the expenses of going to a university. Less valuable but potentially useful awards would include tours of scientific laboratories, offers of a summer job and an opportunity to do research or to attend an international congress.

The types of problem tend to vary with the character of the contest. In a question-and-answer contest, the most difficult part is making up the actual test or examination. If the examination is not good, the contest is not good. The test must be difficult enough to challenge the students, but not so difficult that it fails to identify the winners clearly.

For less formal contests, the questions should be developed with a view to the contest being amusing and fun as well as a competitive test. If the dimensions of a contest are international, differences in national curricula make it that much harder to develop a good test. In contests which call for practical work, safety is a vital consideration both during the contest and during the period in which the preparatory work is being carried out. Checks on safety must be especially rigorous if candidates are called upon to handle dangerous chemicals or devices that give off radiation. With contests of the essay type, particular care is required to ensure that the student has done all of the work on his own. It is only too easy for a teacher or a parent to help, or for a student to copy material from some other source. The determination of just how much of the submitted essay is the original work of the candidate is no easy matter.

Conducting a science talent search

A science talent search, as its name implies, is a competition aimed at identifying students who are talented in the fields of science, engineering and technology. It has certain characteristics which differentiate it from other contests. In looking for future scientists, emphasis must be laid on the quality of an independent research project carried out by the student as an individual and not as a member of a team. This will probably be reported by the student in a paper similar to that which a scientist might submit. It is to be expected that the best projects will be of a very high level, and may be comparable to those of undergraduates, or, in some cases, of graduate students. The judges may therefore wish to utilize three methods of considering the student's research: the written research paper itself, an oral presentation and an interview.

Personal data will also be required. They can be given on a special form. In addition to the candidate's academic record, information would be included concerning the university of his choice, his desired occupation, his out-of-school activities and family background, and answers to questions designed to provide an understanding of his scientific attitude, scientific creativity and inventiveness. Comments and recommendations from teachers and advisers may also be included.

From the foregoing, it is evident that a science talent search is a high-level activity requiring careful management. To begin with, it calls, ideally, for a professional administrator who can take responsibility for the administrative aspects of the organization. It is, moreover, a programme which needs funds to cover administrative costs and, where scholarships are involved, funds to cover these costs as well. Support is also needed from relevant institutions of education, particularly a place where projects can be carried out, with the necessary equipment and services.

Because of the high level of the work to be judged, it is important to engage research scientists as judges, and, of course, ones who are familiar with the special fields in which the students will have worked. Clearly, too, judges should be persons who are willing to devote a considerable amount of time to assessment. It takes quite a while to read a research paper and to give it serious consideration. For this reason, it is desirable to pay the judges an honorarium of some sort if possible, although the amount may not be sufficient to compensate them for the time spent. As to their number, this depends upon the number of entries and the range of work presented by the candidates as a group.

Experience has shown that the greatest single problem in mounting a science talent search is that of enticing students to take part. This reluctance may stem from various considerations. One may be the work required: to prepare for a science talent search requires a great deal of effort on the part of the student, and many do not believe that they are capable of the quality of research required to have any chance of winning. 'Writing it up' is also a deterrent. Many students who are skilful in research have considerable difficulty in writing up their results. Here, the teacher and parents can help. Students who will not proceed on their own will often do so with encouragement. The dedicated teacher is the key to convincing the student that he can do research; by advice, help, prodding the student to write the report and helping to prepare the entry materials, the teacher can be of enormous assistance in encouraging the student to clear the many hurdles.

5. Visits, excursions and camps

Visits and excursions

A scientific visit or excursion may have a variety of objectives. An obvious one would be to acquire knowledge of the state of scientific and/or technological development in the community through direct observation and experience. Another purpose might well be to supplement the theoretical knowledge acquired in the classroom. Alternately, the visit may have a sociological purpose: perhaps to offer the child or young person a chance to initiate or increase his experience of team work, and to study interactions between man and the environment. In any event, every visit should be carefully planned. The accompanying teacher or counsellor should have prior knowledge of the place to be visited, and should, of course, obtain the necessary authorization from the institution concerned. In some cases, it might be prudent to obtain the parents' approval in advance.

The participants should be carefully briefed before the visit so that they know what they are expected to do on arrival, and how they are to do it. They should also be briefed on what equipment, techniques and preparation they may need and given some idea of what they can expect to get out of the visit.

If a visit or excursion is to be a major undertaking, involving considerable travel away from the school's locality, the organizers should study all the circumstances of the outing, from beginning to end. They will look into likely weather conditions, transport needed, safety factors, timetables, clothing requirements, equipment, the degree of prior understanding on the part of participants, the specific interests of the group or of some of its individual members, the possibilities for photography, food, pauses for rest or discussion, places of possible interest nearby, and so on. It is important for the teacher or counsellor to pay particular attention to the safety of young participants during the event. He should give them appropriate information about the elementary precautions to be taken, and make sure that the group is aware of how to proceed in the event of an emergency. He should also have first aid materials of the type appropriate to the excursion, and see to it that the participants can use these materials. Behaviour, too, is very important. In this context, the teacher should help to develop in the pupils a sense of respect for and love of the environment, and emphasize the need for its conservation and protection. Advantage should be taken of any opportunity to point out damage caused by natural agents or by mankind which could subsequently form a subject for discussion.

Evaluation

A well-planned visit deserves to be analysed both for its successes and for its failures. If such an analysis is carried out by means of questionnaires and discussion, this will help to optimize similar future events.

Records should also be kept, individually or in groups. They should take the form of a report which will summarize findings and experiences, re-formulate ideas and adapt them for appropriate transmission, and note conclusions about the aspects studied. The report should contain information obtained in the field and the general results of any activities carried out. The report might well include drawings, photographs, comments, samples gathered and information obtained in the field or emanating from the organizing teacher.

The summary below lists the main items in planning for visits and excursions.

Summary

1. Select the area to be visited and decide on the outcomes desired. If the organizing teacher is not already acquainted with the place, he should visit it before the event in order to examine all relevant conditions and possibilities.
2. Encourage interest: invitations, talks or discussions with potential participants.
3. Prepare a plan of activities.
4. Prepare and dispatch information to parents and authorities, and invitations to preparatory meetings.
5. Obtain assistance, resources and equipment.
6. Prepare supporting material.
7. Meet with participants before departure in order to impart information, collect parental authorizations and advise on work to be carried out, attitudes required of the participants, action to be taken in the event of emergencies, etc.

8. Check up on attendance, equipment, provisions, etc. immediately prior to departure.
9. Carry out the excursion as planned.
10. Organize and interpret data obtained, with a view to making a written record.
11. Discuss with participants the preparation of the final report.
12. Allocate responsibilities for making known the results of the event (talks, publications, displays).
13. Compile data about the excursion and file them.

Science camps

A science camp is an organized group activity, usually carried out during the holiday period and lasting from several days to several weeks. Its normal purpose is to give the young participants (campers) an opportunity to gain first-hand knowledge of biology, zoology, ecology and so on. A social purpose is also present, that of giving the young campers the opportunity to work and live together with their peers.

In general, there are two main types of science camp: one is a camp organized in a distant or remote place where a planned project or research study can be carried out and probably involving outdoor camping; the other is a camp arranged in an established institution such as a university, or in a field-study centre.

Science camps, like visits and excursions, need to be organized, but in much greater detail. The intended project or research study needs to be thought through, taking into consideration the resources of the location and the time available. If camping out of doors is involved, the venue must be identified, agreement reached with the owner of the site, and the implications for transport looked into to establish feasibility. Other important considerations are accommodation, meals and recreation. Safety must be ensured as far as is humanly possible. This implies seeking out potential hazards, both physical and human, and establishing liaison with the police and with local health authorities.

When the possibilities and requirements of the campsite have been clearly established, the organizer will be able to turn his attention to costs and how they will be met, the selection of participants, seeking the approval and support of parents and arranging insurance cover.

The nature of the activities will depend on the local environment and on local interests. Generally speaking, the activities will assume the form of a project. This may involve making a survey or carrying out an investigation. Some examples (taken from an African environment) are as follows:

A survey of people affected by malaria, bilharzia or sleeping sickness in a specific area, combined with a study of the diagnosis, treatment and elimination of those diseases.

A study of the tse-tse fly scourge and its effects on domentic livestock in a specific region.

A survey of children affected by kwashiokor and of infant mortality; diagnosis and treatment; and the steps taken to prevent these deficiency phenomena through guidance on appropriate diet in village education programmes, etc.

A survey of hot springs, including the study of plant life and soils in the area, and an evaluation of mineral deposits.

A study of rural fishing techniques, including rural boat and canoe building.

A study of the problems of storage of grain, maize, fish, bush meat and other foods.

A classification of the natural habitats of wild animals, their living and migratory patterns.

Identifying the flora and fauna associated with certain animals. (Such an investigation would best be carried out in a national game park, probably in a field centre established within the park exclusively for this purpose.)

This approach is described in detail for a typical camp in British Columbia (Canada) in Appendix VI.

In contrast, a recent Asian science camp (ROSTSEA, 1984) in the Bangsaen Marine Science Centre of Srinakharinwirot University, Chonburi (Thailand) was concerned with 'Alternate ways of obtaining energy, and conservation of energy'. Participants from eight countries (Indonesia, Malaysia, Nepal, Pakistan, the Philippines, Singapore, Sri Lanka and Thailand) viewed energy problems in the context of their own countries and tried out ideas which could eventually be disseminated.

When a camp is held in an institution of education, the activities are likely to be more laboratory-based and involve the design, construction and use of apparatus to study specific topics. For example, the study of solar energy would involve the design and production of solar water heaters, coolers, distillation equipment, and so on.

Following any science camp, it is essential that there should be suitable activities to produce adequate documentation, including the publication and distribution of reports on the projects undertaken, with suggestions for modifications in future camps. Such assessment or evaluation procedures are essential if the activities of science camps or field centres are to be extended and developed for the benefit of the community. In this respect, it is also essential that the relevant reports and camp documents be submitted to sponsoring departments, both government and non-government, and to other interested individuals and institutions.

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6. Mass media, museums and science centres

The use of mass media in out-of-school science and technology education

Introduction

Of all information-dispensing bodies, be they a part of the education system or not, those of the mass media reach the greatest number of individuals of all age groups and from all walks of life. Information received through the mass media is more readily absorbed by the public, partly because it is not imposed by a single official organ, and partly because it is prepared by specialists according to professional journalistic techniques. Unlike established educational programmes, newspaper articles and radio and television programmes must attract an audience. A boring programme will be switched off, just as an article which is difficult to understand will be put aside. In-school education features set curricula; information of a more general nature changes from one minute to the next, reflecting the tempo of a changing world.

The transfer of knowledge is a building block of scientific and technological progress. New knowledge is generated by an individual creator who, through his discoveries, will contribute to both the order and the complexity of the vast field of the human sciences. These discoveries will be communicated by various means, to be taken up and further developed by other scientists. Thus a chain effect is created, which can be instrumental in the development of a scientific discipline. Today, it would be impossible to separate the realm of science from that of the general public, since the latter pays for, benefits from and, in part, contributes to scientific progress. The mass media are privileged vehicles of this information exchange.

It is traditional for scientists – even those as famous as Faraday, Einstein or Pauling – to speak to the public directly when giving popular lectures. Even so, however brilliant a lecture may be, it will reach only a few hundred people whereas a newspaper or a television programme may be read or viewed by millions. So, the better the organization of scientific information through the mass media, the greater the audience it will reach. For this reason the scientific channel to the mass media should be supported.

The press

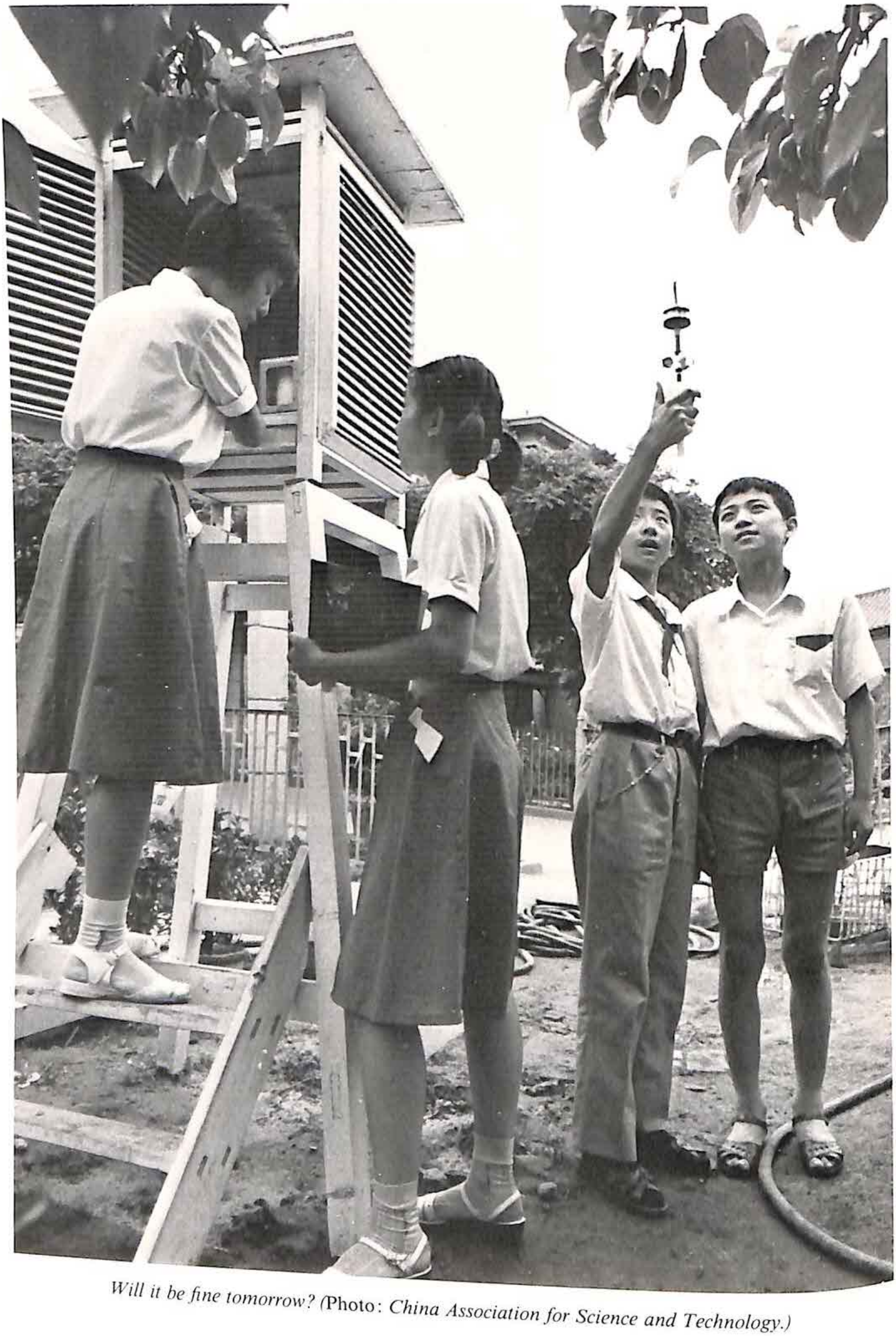
Newspapers traditionally have 'desks' devoted to various subjects which regularly appear on particular pages, where readers are accustomed to finding them. These subjects include world politics, domestic politics, general news (human interest stories, accidents, demonstrations, etc.), sports, features and television. Some newspapers feature a science and technology page, and some devote space to the environment and modern living.

Depending on the editor's policy, the science column is either covered by one correspondent or shared among several journalists. In the larger newspapers – particularly those which attach importance to the science column – several specialized correspondents cover developments in the field and effectively form a science desk. In such cases, each correspondent will have a field of special interest, such as the earth sciences, biology or computer technology. The field of medicine is usually assigned to one journalist. The science correspondents who work for newspapers, magazines, radio and television play a key role in the dissemination of scientific knowledge in an out-of-school context. It is important that they be aware of and sensitive towards the very wide range of age groups, of interests and of knowledge of those for whom they cater.

The role of the press is not confined to reporting the news. Newspapers and magazines can and do serve as links between educational institutions and clubs. Preparations for the science olympiads are announced in the press. These olympiads, as their name suggests, aim to seek out those young people who are proficient in science by testing their powers of imagination and identifying the most promising talents among them. At a more mundane level, a variety of different games and contests relating to science and technology can be promulgated in the popular press: brain teasers, riddles, history, mathematics problems and scores of others may be featured. Even science clubs and associations for young people can be made newsworthy, particularly when some special event is arranged. For example, 'young inventors' contests' for young people are held in many countries; newspapers should be encourged to report on them and lend their active support to such movements.

Field Work. (Photo: *China Association for Science and Technology.)*

Way out of school. (Photo: *China Association for Science and Technology.)*



Will it be fine tomorrow? (Photo: *China Association for Science and Technology.*)

Radio

Radio is unquestionably one of the most influential and important means of transmitting information. Radio is intended for all. It does not require an extensive infrastructure for its broadcast or reception. It crosses mountains, forests and deserts with ease, bringing the news to every household, however remote. Since the listener does not need to be literate, the radio speaks as much to the most underprivileged sectors of the population as to the most erudite. Through transistor technology, radio receivers today no longer need to rely on large sources of power. A few batteries, readily available everywhere, can last for months.

In addition to its informational role, there is another important aspect of radio broadcasting: its power to elicit a response from the listener. The friendly, familiar voice which enters the listener's home diminishes his isolation and is cheering. For peoples with an oral tradition, it is a highly persuasive form of communication.

The very act of broadcasting, the way the text is presented, the use of music and sound effects, all add elements of drama to the radio programme. The range of programmes is vast. Although radio is devoid of visual support, it results in greater concentration on the part of the listener, allowing him to assimilate more effectively the concepts he hears. Besides, the listener can tune in to a radio programme while doing something else: 'music-while-you-work' is now a commonplace.

Science can be the subject of many different radio programmes. Such programmes can be created either by independent producers or by a science production unit. The science correspondent or producer working at the radio station should possess not only the qualities of a good press correspondent but also the special skills required by the professional broadcaster: a pleasant voice, and a 'stage presence' similar to that of an actor. He must also be good at conducting an interview, and be able to read a text in a convincing manner.

The director of science programmes has at his disposal a wide variety of presentational formats. The simplest, perhaps, is one which relates to a news story; this may include an interview with a specialist on the subject. If so, the questions should be brief, so that the responses give the details. But they must also be comprehensive in order to clarify certain points, challenge others and provide additional information on the subject. These programmes, whether broadcast live or pre-recorded, are always popular when the guest being interviewed is a knowledgeable and effective speaker. The list of topics which may be treated includes new discoveries, research findings, biographies of scientists, stories of animal life, ecological issues, technological progress, and so on.

For the purpose of discussing more general topics, radio stations may select participants who will be called upon to answer questions and who are also capable of asking them, thus contributing to a general debate. This type of programme is particularly suitable for discussing major issues such as the pros and cons of nuclear energy, the problems of world hunger and overpopulation, the 'green revolution', the nuclear arms race, erosion and desert formation, research policy and the environment.

Like a good story-teller, radio has a considerable potential for evocation and stimulation of the imagination which can compensate, to some extent, for its lack of visual support. Science reporting can benefit from this attribute. A programme costs much less than would a film on the same subject, and yet provides almost the same amount of information. Equipped with only a tape-recorder, a radio journalist can bring into the home a picture of the life of scientists working in a wide variety of situations: plant reproduction, a visit to an astronomical observatory, deep-sea exploration in a bathysphere, a trip aboard an oceanographic vessel, the construction of a rocket, research on the behaviour of certain animals, and so forth.

Cassette recordings, which may be listened to on small, inexpensive cassette players, are the natural extension of radio broadcasts. Some radio stations already offer listeners cassette recordings of their most noteworthy programmes. A radio broadcast is by nature ephemeral. The listener is left with only a memory of it, and a certain amount of knowledge gained. There are many potential listeners who are unable to hear a programme which might have interested them, either because of schedule conflicts, or simply because they were unaware that the programme was being broadcast. For these, a cassette recording of the missed programme can be a most welcome acquisition. Special report radio programmes are the most obvious candidates for cassette recording. Others, on specific topics, may be specially adapted to the needs of individual countries. Cassette recordings are either marketed directly by radio stations or made available in stores. They can be distributed for use in schools, and may also be linked to a slide presentation.

Television

Television is a window on the world through which viewers can enter places which are not normally open to them and meet people they would not otherwise be able to meet. The viewer feels that the television host and journalist are present in his home, and, in a sense, a personal form of communication is established between television performers and their viewers.

It is equally true that the televised image has the power to captivate, which is particularly felt by young people. It would therefore be unthinkable not to take advantage of the power of this medium to disseminate scientific information.

The existence of a picture enhances television's ability to transfer the viewer to the scene of the action. He may find himself participating in major scientific events, addressed by scientists who look him straight in the eye. At a more intimate level, the viewer can become the doer. Through the television image, processes may be visualized and demonstrations may be backed up by experiments, models and animated sequences. Abstract concepts thus become easier for the viewer to understand. Special film technology makes it possible to speed up or slow down the image. The various stages of an experiment which took an entire week or longer to perform can be condensed into a few minutes. While the radio can braodcast the voices of scientists, television can actually show them at work. A picture will reveal the size of a device or machine and can demonstrate the difficulty and complexity of scientific research.

Educational television has developed alongside commercial television. Educational broadcasts can be more didactic and stricter in presentation. Many countries exploit this feature, and countries such as India have carried out experiments in educational television by satellite: for these, special programmes are, of course, produced. The benefit of such a system lies in the fact that the same television equipment can be used to broadcast science, technology, or educational programmes of value to adults.

Many programming techniques can be used to convey scientific and technological matter. One is the news feature programme. In, say, a fifty-minute broadcast, three or four carefully chosen stories on basic research, technology, biology and medicine can be presented. These stories are pre-recorded, then assembled and linked by a commentary.

Television reports are also popular. Unlike the short news feature stories, special reports are an excellent way in which to introduce the viewer to the world of science. They can represent a great adventure in a sequence of episodes. Possible topics for this kind of programme are legion. A visit to a biological research centre in Africa will provide an opportunity to examine the activities of a group of scientists, as well as to point out the problems encountered in tropical regions. A programme on the work of glaciologists will show laboratory research on climatic development following an expedition to the Antarctic. Research on epidemic diseases at the Institut Pasteur in Paris will furnish an opportunity to visit various regions afflicted with diseases spread by flies, fleas or mosquitoes.

Tropical agronomy and soil protection in hot climates can be studied in research centres adapted to specific climate and soil conditions. Operations in progress, laboratory research and interviews with scientists and local people who express their needs and hopes on the subject can all be used by the producer. The story can be dramatized in a number of different ways, such as following a person in his daily work or observing the everyday life of a family.

Filmed documents can play a vital role, either because they feature special effects, or because they have been shot under special experimental conditions, providing flashbacks to an earlier stage of experimentation. They may be obtained from specialized film archives, national and foreign television archives, or the cultural services of embassies. Many research centres produce films to promote awareness of their work. Simple film footage can often serve as a highly effective working tool. Small children at play, who are unaware that they are being filmed, can furnish valuable insights into early social behaviour. The same technique may be used to observe animal behaviour. Microscope cinematography opens an entirely new world to the viewer: through X-ray photography, for instance, he can witness the transformation of a butterfly pupa into a fully developed insect.

Television programmes can provide a first-hand look at major scientific installations: star gazing in an observatory, oceanographic research on a vessel using modern diving gear, oil drilling platforms, and so on. Filming events of this type requires meticulous preparation, the establishment of relays, the installation of cameras in strategic places, and the development of a variety of different tricks used in order to transmit images from difficult-to-film places such as glaciers or mine-shafts.

Television has a great appeal for young people. They are eager to learn about the modern world and television can take them directly into the world of science. Science club programmes are especially popular. A science show host can perform experiments for the children in the audience and carry out amusing demonstrations in order to explain physical, chemical or mechanical phenomena. He can show them how to raise insects and introduce them to the secrets of nature. Demonstrations on magnetic boards using bouncing arrows, flying saucers and moving trains are very amusing for children. Experiments performed with temperature and liquid gases can open new horizons to the young mind, and the resulting optical phenomena and illusions are easy to demonstrate. Children can interrupt, ask questions and participate in the experiment themselves. This technique can be developed and used for adults as well.

Scientists are aware of the importance of television and its audience appeal. Science programmes provide scientists with an opportunity to report on their work and thus they are eager to participate.

Science museums and science centres

A science museum or science centre is usually a nationally sponsored institution with full-time professional and supporting staff. Their function is to provide an informational and educational service for the community in the fields of science and technology.

Many science museums are established by government departments and are financed through the state budget. Some open their doors without charge to the public in general and to school parties in particular; they are open, like any other museum, throughout the year. Others charge an entrance fee to offset running costs.

Museums can be classified functionally into museums of natural science and cultural museums. The first group represents structures which exist in nature independently of man's intervention; the second is concerned with collecting and exhibiting objects produced by human hands. The majority of museums – those devoted to art, ethnology, history of civilization, etc. – belong to the second group. Museums dealing with natural history, geology, palaeontology and mineralogy belong to the first.

Most 'modern' museums are comprehensive – in the sense of combining the functions of both groups. In their cultural capacity, they display the machines and technology of the past, and thus present objects produced by human hands; at the same time, they seek to demonstrate the physical laws which are at work in machines or technology.

Many countries have just one science museum divided into sections (or galleries, as they are often called) for different aspects of science and applied science. In some countries, there are separate museums for natural history, geology and astronomy, and even for separate sciences and engineering. There are also separate planetaria and space museums.

Many of the science museums – such as the Science Museum, London – have been in existence for a century. Many developing countries, however, have only established science museums within the last two or three decades.

While the initial function of museums was to house, catalogue and display items of apparatus of historical interest – often as part of the cultural and scientific heritage of the country concerned – the modern science museum is regarded both as a display centre for contemporary science and technology and as the source of an historical account of developments. Moreover, modern-day museums are designed to educate and popularize through participatory experiences in which the visitor can operate models and perform a variety of scientific experiments on them. This type of exhibit is more difficult to arrange and may take many weeks to devise, since each working exhibit must be capable, first, of operating by a push-button or some other device and, second, of replicating the experiment time and again, with the minimum of maintenance.

Some science centres also encourage schools and other groups of youngsters (e.g. in science clubs) to display their own exhibits – for the general public – on the occasion of science fairs or special science days.

Many museums put on a programme of lectures and demonstrations at specified times for the public in general or for parties of schoolchildren on an out-of-school visit. Others encourage science teachers – through their professional associations – to use the facilities and rooms for their meetings.

> The attractiveness of the working models which serve to illustrate man's view of the world and the influence it has on every aspect of life including technology, inevitably elicits an emotional response from the public, with the natural result that many visitors, particularly young people, obviously care much less about acquiring knowledge by exercising their intelligence than about the enjoyment and amusement to be got out of brainless 'playing about' with the apparatus. A tendency displayed by many visitors to indulge in unrestrained and even aggressive behaviour has unfortunately made it necessary to replace the three-dimensional and accessible models of experiments which it was previously customary to provide, allowing the visitor to 'take a hand' in the processes himself by automatic, and often complicated, equipment, viewed at a distance through glass panels and producing its effects at the touch of a knob (Auer, 1974, p. 74).

This situation, where the science museum has to reconcile its serious educational task with the need for amusing, light-weight displays, is a challenge to the skill of the museum expert: he has to awaken the visitors' curiosity by presenting the exhibits in an attractive way, but must then hold and stimulate their interest, using such means as audio-visual aids, until they have grasped and assimilated the intellectual content of what they are seeing. Only if the museum succeeds in creating this close and truly personal contact between exhibits and visitors will it be able to fulfil its proper educational function.

It will always be the ultimate responsibility of the science museum to arouse people from their mental inertia and lift them out of the superficiality of their everday existence, to broaden the rational basis of their knowledge about nature and so bring them face to face with the immutability and universality of its laws and with all the phenomena that stem from causality.

By unfolding this stupendous, all-embracing and harmonious view of the world, the museum may even hope to impress the 'iron laws' of physical nature so strongly upon its visitors that the experience will lead them to reflect on the logical clarity and inexorable consistency of these natural laws, as compared with all the contradictions evident in the attitudes of human beings – whether behaving as individuals or as social groups – towards ethical standards, whose repeated neglect has plunged man into disaster throughout history.

Mobile museums

In many countries, such as India, more than 75 per cent of the population live in villages. The problem of out-of-school education in science and technology for the village dweller is very difficult. Some attempts have been made to solve this problem through mobil exhibitions compiled and shown by a central museum. In India, for example, the mobile science exhibitions of the Visvesvaraya

Industrial and Technological Museum, Bangalore and the Birla Industrial and Technological Museum, Calcutta, have made a considerable contribution to the task of bringing science and technology to the villages and relating science and technology to village life.

A programme of visits by a mobile science exhibition might last for sixty days, spending on average three to five days in each village or small town. The emphasis would be on simple participatory exhibits, with maximum impact through audio-visual effects and with a minimum amount of written text.

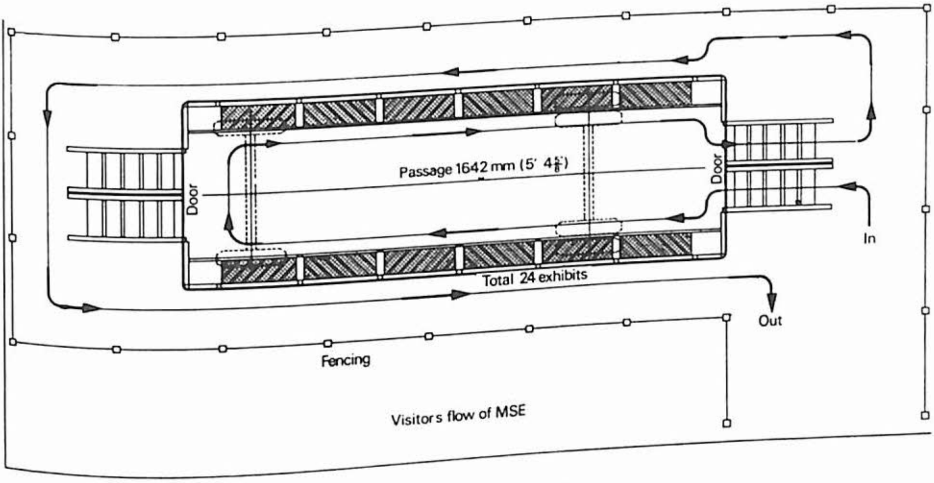


FIG. 10. Diagram of the Mobile Science Exhibition, Bangalore.

Organization and finance

Science museums and centres are usually managed by a governing board or by trustees who appoint the director and full-time staff. The cost of acquiring exhibits, designing working models and displaying them in halls of sufficient size to permit the public to circulate freely is considerable. The cost of the full-time staff, including the technical support staff (carpenters, electricians, etc.) is even greater. Thus most national museums will receive government subsidies, even if they attract large numbers of the public who may pay an entrance fee. But they provide a vital service in the popularization of science and in the provision of out-of-school activities for young people.

Reference

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7. Training, evaluation and general issues

Training

Advantages of out-of-school science activities

Out-of-school science activities have many advantages, each of which illustrates the type of leadership and training required by those adult sponsors or advisers who are involved with this work. The principal benefits are the following:

1. They involve students in the practice of science as it actually is. Building a small wind tunnel, running a weather station, doing research on the biochemistry of crab cuticle hardening, or working as an assistant in a medical laboratory all involve students in 'doing' science. Such experiences are often in direct contrast to the preciseness and predictability of the more usual kinds of school experience. For example, a student doing a research project on the biochemistry of the hardening of the crab cuticle probably started by being interested in nature, and, later on, specifically in crabs. He must have asked himself questions about the shells of crabs, perhaps because of observations at home or along his neighbourhood seashore. This would have led to his reading about crabs, and then, as his interest became more specialized, to undertaking some experiments. These would have involved a need to know something about chemistry and biochemistry, which in turn would have suggested specific questions about the cuticle, leading to the specific research carried out.

What is lacking in formal education is the opportunity to combine a group of such disparate interests, activities and learning into a single purposeful and interrelated whole. Science youth activities provide this opportunity and, in addition, have other characteristics that differ from the formal curriculum: they are complex, sustained over a long period of time, and often voluntary; they involve recognition and formulation as well as the solution of problems; and they are relatively 'open-ended', with no exact predetermined, specific answer. In short, they resemble, though admittedly in a very simplified form, the kinds of conditions in which real scientific research is carried out and provide a realistic introduction to research, a kind of experience that cannot be duplicated in any other way.

2. They motivate through doing. Competing in a science contest, taking high-speed photographs of water flowing through a pipe, building a laser or working on a vaccine are all activities which involve the students in doing something.

Young people's interest in taking an active rather than a passive role is very important; hence the intrinsic appeal of science youth activities. All too often students are talked to, lectured at and demonstrated to, and asked to watch films; the only breaks come when they are asked to repeat some of the information in the form of an oral recitation or written test, or when they are put into a laboratory to go through certain repetitive exercises, many of which are predetermined.

Science youth activities can provide a genuine appeal through exploiting the inherent pleasure that all people have in exercising their capacities, in gratifying the urge to participate as well as to watch or listen, to do something for the sheer enjoyment of doing it and to experience the excitement of exploration and discovery.

3. They motivate through providing choice. Deciding to participate in a junior science academy meeting, choosing a topic for a research project, working nights and weekends on a scientific hobby, or taking a summer job as a laboratory assistant – these are all activities in which the students make their own choices about the nature and extent of their participation.

Obviously when students can take responsibility for decisions about their own activities, determining what they will do and when they will do it, there will be an increased motivation to undertake their self-assigned tasks to the best of their abilities. Moreover, such self-directed interests may endow classroom work with a new relevance, as well as revealing a need and a use for science that hitherto might have seemed unimportant.

No matter what the students are doing, their personally selected project takes on a significance far greater than it would under other circumstances. Moreover, it provides a kind of challenge that is substantially different from that of the classroom, a challenge to which most students respond.

4. They encourage individual responsibility for learning. Making astronomical observations, designing and constructing a computer, studying the effects of vitamin D on mice or solving puzzles – these are all activities which help students to take individual responsibility for learning rather than simply waiting for the teacher to assign them the material.

No teacher can provide in-depth supervision for all the variety of activities which students think up and, even if it were possible, the complexity of modern science is such that no teacher could be equally expert in such a wide range of fields. Once teachers accept the fact that students may surpass them in their specialized knowledge, they can freely encourage them to go ahead on their own; thus what might have been considered a difficulty can actually be turned into an important advantage. The teacher's role becomes that of general adviser, suggesting sources of information or material and encouraging those students who run into difficulties with their projects.

Students should be encouraged to take more responsibility for learning. Sooner or later, no matter whether a young person becomes a scientist or not, he will be thrust out into the adult world, where his success will be dependent, in part at least, upon individual abilities. The student will not have a teacher, or even a supervisor, to tell him all the things he ought to know or do. Success will depend upon the ability to decide what is important and to go about learning for oneself.

Science youth activities can make an important contribution to teaching individual responsibility for learning by encouraging students to explore on their own at an earlier age. Moreover, this is done in a situation where students can obtain help if they need it, and where mistakes are not as serious as they are later on in life.

5. *They enable students to investigate subjects at a greater depth than that permitted by the regular curriculum.* Attending a science camp, hearing lectures by a prominent scientist and going on a tour of a power station or nuclear reactor – all these give students information and background beyond that possible in the regular classroom. They permit students to follow their own interests and curiosity; they allow them to investigate unanswered questions raised in classroom discussion; they permit students to go deep enough into a subject to feel that they have a grasp of it; and they allow them to find out about questions for which there are as yet no answers and to learn that science does not have all the answers.

Time for formal curriculum work is essentially limited. Most new curricula have a great deal more ground to cover than ever before and both teacher and student are under considerable pressure to assimilate vast amounts of material. This means that there is little flexibility in what can be done, and little time available in class to cover anything that is not absolutely essential.

Science youth activities enable students to explore some of the non-required but nevertheless interesting areas of science.

6. *They provide a more realistic kind of career guidance.* Students who have worked in a laboratory will have a far more accurate concept of science than can be gained from textbooks or the mass media. This is important, since in our modern technological society, it is increasingly difficult for young people to

make career choices with any degree of certainty. They have little opportunity to observe people at work, and so must make their decisions on second-hand evidence, much of which is too superficial to be of any value.

Science youth activities provide opportunities for them to learn about science as a career directly – from talking to scientists, from visiting them in their laboratories and from working with them, and from carrying out various types of scientific investigation.

7. They indicate qualities not revealed by the usual examinations or tests. If a student wins a prize in a science fair project, voluntarily participates in a seminar conducted by a scientist, works long and hard as a laboratory assistant or wins a science contest, what does this mean? There is now reason to believe that many of the qualities essential to scientific success – and, indeed, to success in any field – cannot be identified by standard examinations or tests. Originality, independence, initiative and persistence are all qualities which the more traditional forms of examination fail to identify with any degree of accuracy. But if a student undertakes a difficult research project, stays with it, endures frustrations and lack of progress, and finally comes up with original results, this is significant. The same is true if a student takes part in a seminar in his own time.

This is not to suggest that academic achievement is unimportant. The point is that all it does is predict academic achievement later on. Obviously, one must have a good education to succeed. But academic achievement does not predict, for example, which science students will make the best contributions as scientists. However, there seems to be a good chance that predictions will be improved if one takes into account students' performance in science youth activities.

8. They teach how to communicate. Exhibiting at science fairs and explaining a project, making an oral presentation at a conference, writing a paper for submission to a science talent search, giving talks to adult groups, preparing exhibits for local museums and tutoring other students in science are all activities which require students to communicate. They must thus not only have a good command of science, but also know how to use written, oral and visual communication techniques.

These activities give students some experience in communicating scientific matters to persons other than the teacher, and in situations very different from the classroom. Moreover, they provide the kind of motivation necessary to learn about communication – writing, organizing, etc. – that classroom activities may not provide.

9. They bring students of similar interests together. Attending a science camp, participating in a science olympiad, going to a meeting of a science club, making a presentation at a seminar – all these are experiences which bring together students with an interest in science. Such students derive encouragement from working with and talking to each other, and this collective stimulation provides powerful motivation to undertake further work.

Meeting with their peers also gives science students a chance to exchange information and to learn from others. Some may have similar research projects and can discuss their successes and failures. Others may compare experiences at olympiads or other contests. By observing the older students, the younger ones may be stimulated to make greater contributions in their scientific work.

10. Learning can be fun. Competing in an olympiad, studying comets through a telescope, participating in a contest and doing research on the genetics of corn all involve learning that could be said to be disguised as recreation. Almost all out-of-school scientific activities fall into two general categories that resemble major activities of mankind: hobbies and contests. Both these activities create a motivation and drive that at times can become obsessive.

It is perhaps not easy to explain the appeal of hobbies for most people, yet we have all witnessed the passionate interest generated by real hobbies – viz. amateur astronomy, butterfly collecting and amateur radio operating, as well as less technical hobbies such as stamp collecting, gardening, keeping pets, building model ships or aeroplanes, and so on. Similarly, it is perhaps not easy to explain the appeal of contests: not only sports contests, but also chess, bridge, kite flying, flower shows, and so on. The real enthusiast displays an almost overwhelming dedication and sense of direction.

As most out-of-school scientific activities are similar to hobbies or contests, some of the same motivation develops in the students. An individual research project often develops into something like a hobby. The person continues to work for the sake of the project and the satisfaction derived, a motivation that is not always clear to others. The student who becomes involved in a contest is similarly absorbed, often spending long hours in practice and preparation.

For these reasons, students involved in out-of-school scientific activities can be motivated in a way that is completely different from the way they feel about school.

11. They have the flexibility to adapt to student needs. A science club's programme, the events in a science olympiad, the selection of a field trip or the events in a contest are flexible and can be adapted to the interests and abilities of the participating students. Most classroom work is aimed at precise objectives in terms of learning on the part of the class. This leaves little room to vary the programme to meet the individual needs of the students. Out-of-school scientific activities, however, do not have to conform to such specific demands.

Science fairs can be large or small. The events in a science olympiad may be whatever the students and sponsors desire. Clubs may have only one activity or a number of different ones. A contest may have one or two simple events or a number of very sophisticated ones.

For this reason, out-of-school scientific activities will vary from school to school, or from year to year. This means they have the flexibility to respond to changing participants, increasing knowledge of science as the students grow older, contemporary needs, the interests of the community and the abilities of the adult sponsors.

12. They provide recognition for the school. When parents or other members of the public view the exhibits at a science fair, watch a science olympiad or see publicity in the media about the winners of an olympiad or science talent search, this provides recognition for the school as well as the students. Similarly, students who prepare an exhibit on conservation for the local library, or survey the use of pesticides in the locality, provide recognition of the school through community service.

Parents and others do not have much opportunity to see students performing in the classroom, but science contests can have the same kind of attraction as sports contests; properly conducted, they can focus public attention on schools and their achievements. Similarly, various kinds of community service by the students can focus attention and generate good will. Thus out-of-school science activities can be a showcase for excellence, and provide valuable public recognition for the schools, as well as for students and teachers.

Leadership and training

The identification of leaders for out-of-school science activities is obviously crucial to their success. Within the school system, there should ideally be at least one leader per school. He could be, and usually is, one of the science teachers with a particular interest and commitment to the work involved.

Outside the school system, a leader could also be a science teacher who is prepared to help youths and adults in out-of-school science activities such as organizing science clubs, science fairs and exhibitions. He may also be an interested scientist, not necessarily a teacher, but it is essential that he have some knowledge and understanding of science and its applications, a desire to work with young people, and the time and energy to devote to the work.

The leader of out-of-school science activities should be given the necessary recognition by the appropriate authorities – the school itself, the local Directorate of Education, the Ministry of Education or Ministry of Youth, and other agencies. If finance is available, leaders of out-of-school science activities should be offered additional remuneration in the form of fees or honoraria, as a mark of recognition of the importance of their work. In some countries, it is possible to appoint full-time leaders on a salaried basis. As a minimum, the out-of-pocket expenses involved in organizing the activities should be reimbursed.

Periodic retraining of leaders is essential. This could take the form of workshops organized by the national or local authority and might provide opportunities for the leaders to widen their sphere of activities through training in woodwork, metal work, electronics, photography, computer programing, repair and maintenance of laboratory equipment, and so on. One of the most effective forms of training, however, is informal: leaders are encouraged and enabled to attend events within and outside their own region or country in order to compare what they see with their own ideas and to learn from others involved in similar work. Both the formal type of training course for leaders or potential leaders and the informal type of training will require financial support, but the long-term benefits to out-of-school science activities can be considerable.

From time to time Unesco organizes special workshops, seminars and symposia to assist with the training and familiarization of leaders of out-of-school science activities. For example, a five-day workshop on 'Out-of-school Science and Technology Activities' was organized in Dhaka from 16 to 20 March 1984 under the auspices of the National Museum of Science and Technology, in co-operation with the Bangladesh National Commission for Unesco. Twenty-two government school teachers from all over the country, seventeen members from different science clubs and eight people from the mass media participated in this workshop, at which the principal questions relating to the further development of out-of-school science and technology in Bangladesh were discussed.

In 1982 the Second International Seminar on Out-of-school Activities in Chemistry at Secondary School Level was organized in Bratislava (Czechoslovakia). The participants came from eleven European countries.

A Sub-regional Workshop on Out-of-school Scientific Activities and the Popularization of Science and Technology in the Arab States was organized in Tunis from 10 to 14 November 1981. The Workshop was attended by twenty people from six Arab countries. In 1984 two sub-regional workshops were organized in Morocco and Bahrain.

Fifteen participants from fourteen countries attended the Workshop for Key Personnel Concerned with Out-of-school Scientific Activities by Young People, organized in Bangkok (Thailand) from 24 August to 2 September 1982. The role of out-of-school scientific activities, in both formal and non-formal education programmes, was discussed, and experiences in the planning, organization and evaluation of out-of-school scientific activities were exchanged. Trends, problems and issues were identified.

In 1984 two regional workshops were organized in Latin America: the Quito (Ecuador) Regional Workshop for Promoters of Scientific and Technological Activities for Youth, and a Seminar/Workshop on the Popularization of Scientific and Technological Knowledge in Out-of-school Education in Tegucigalpa (Honduras).

In 1982 two workshops devoted to the development of out-of-school science and technology education were organized in Africa: in Lomé (Togo) in January, and in Lusaka (Zambia) in August.

In Europe, the tradition has now been established of organizing, every two years, the European Round Table on New Trends in Out-of-school Science and Technology Education. The first was held in Bonn (Federal Republic of Germany) in December 1982, and the second in Brescia (Italy) in December 1984.

Evaluation

The evaluation of an out-of-school scientific activity provides feedback to the adult sponsor or other interested persons indicating how close the activity has come to attaining its objectives, and in what ways the programme might be improved. The following questions may serve as a checklist for evaluation:

1. Has there been an improvement in the understanding of the child or young person of the concepts and processes of science and technology?
2. Has the young person's capacity to explain the phenomena of the world around him improved?
3. Is he aware that technology involves a scientific base?
4. Has he carried out a project of interest revealing a creative intent and a readiness to think creatively?
5. Has he been capable of establishing clearly and precisely the objectives, processes and results of his work?
6. Has he learned to work as part of a team?
7. Has he learned to live in company with and collaborate with other fellow students and teachers?
8. Has he shown an awareness of the duties and responsibilities of community life? Is he prepared to accept and fulfil them?
9. Has he shown an awareness of the search for truth as something essential to his advancement?
10. Has he learned to question, arrange and systematize the information acquired as a result of a search for knowledge?
11. Has he acquired a capacity for critical thought?
12. Is he able to study facts without being diverted by preconceived opinions or ideas?

13. Has he progressed in terms of responsibility, tenacity and discipline?
14. Has he learned to be humble and to accept both success and failure?
15. Has he realized that each stage of a project leads to new questions?
16. Has he understood that scientific and technological investigation is subject to moral rules?
17. Has he acquired full consciousness of his duty to respect nature scrupulously?

An evaluation can range from a consideration by the adult sponsor of what has been achieved during the year to an elaborate study involving group discussions, interviews, questionnaires and extensive analysis. All evaluations, however, must be deliberate and should result in some sort of written report that can be kept in the records for future reference.

An evaluation has other uses as well. If the evaluation is positive, and shows that the activity is successful, it may also be used to convince the administration or other financial sources to continue or to increase funding. It can also be used to encourage additional participation in the activity on the part of students, teachers, scientists, parents or the community. A 'success story' is always appealing, and can be very useful.

There must be a set of programme objectives against which achievements are measured in order to make an evaluation. This sounds obvious, but many people ignore it. The objectives may be very simple, such as 'doing better than last year'. But if it is noted that, the previous year, a club had twenty-five members, met ten times, had three scientists give lectures, and so on, then the objectives are actually fairly specific. For activities on a wider scale, objectives are even more important, as they may contribute to administrative decision-making and help obtain budgetary support.

Objectives can be qualitative or quantitative. Thus one might have as an objective simply 'to form a science club' or 'to form a science club with at least ten members'. The former is qualitative, the latter quantitative. Other quantitative objectives include: to have a specific number of participants as club members, in science fairs, and so on; to hold a specific number of club meetings and science fairs and to secure a specific number of schools to take part in olympiads; to secure representatives from a particular geographical area; to arrange a wide range of activities – clubs, readings of papers, science fairs, olympiads and science talent searches; and to keep within a certain budget.

Some objectives are defined in essentially qualitative terms. These might perhaps relate to procedures, such as ensuring that all the judges at a science fair are scientists of some standing. Other qualitative objectives could relate to winning specific awards or to attaining certain standards. Other objectives may be defined not in terms of what happens in the immediate future but, rather, in the long term. Thus one might, for example, aim to have more students choose science as a career than previously, or to have more students pursue science in higher education or, more simply, to have more students opt for science courses at school.

The scope of an evaluation may range from a meeting of several adult sponsors to evaluate the activities of a science club to, perhaps, an elaborate follow-up study of olympiad participants to discover what their careers were ten years later. The methods used to evaluate out-of-school scientific activities tend to be relatively unsophisticated, because they are usually carried out by the adult sponsor or by students rather than by professional programme evaluators. This does not mean, however, that the evaluations are less important. Methods used can include discussion, questioning, interviewing, scanning records, direct observation or simply soliciting suggestions. Thus a meeting of the members of a science club with those who organize and run it to discuss an activity which has just taken place is a simple form of evaluation. This can be supplemented by questioning, either in an interview or in writing.

Suggestions can be solicited by placing a box for written proposals in some convenient place. In essence, the question here is 'what do you have to suggest?' More detailed proposals can emerge from a list of questions which can be put verbally or in writing to a selected group of respondents.

If good records are kept, evaluation information can be obtained without questioning. In fact, using records can be one of the best and easiest means of making an evaluation. Such records can include information on the number of participants in a relevant activity, the programme of activities themselves, successes (and failures) and, of course, previous evaluations. Direct observation can also be an effective way of evaluating a science club or other out-of-school activity, providing the observer has wide experience and is an expert in the area of science he is called upon to evaluate.

The quality of the evaluation will also depend on how well the observer is briefed. The more specific the briefing, the more valuable the report will be. This report should be obtained as soon as possible, while the observer still remembers what happened and can discuss any points arising or clarify any outstanding issues.

Responsibility for initiating an evaluation usually lies with the adult sponsor of the out-of-school scientific activity. He should have a clear understanding of what it is that the evaluation is supposed to accomplish and should be capable of formulating objectives for the evaluation. The initiator should propose or decide upon the methods which seem appropriate, and suggest or choose someone to carry out the work, if an external evaluator is necessary. When all approvals have been secured, action can be taken and the evaluation can proceed.

The report of the evaluation, when it is received, should be discussed as soon as possible with a view to implementing acceptable recommendations. It can then be filed for future reference.

Some issues

There will always be problems, and problems inevitably raise issues. The problems connected with out-of-school scientific activities can be grouped into four different categories: general policy questions affecting most activities; problems involving student participation; problems involving the participation of adult sponsors; and problems affecting support for activities. In the second category, the question of compulsory versus voluntary participation usually arises in the context of science fairs and has therefore been discussed earlier (page 54).

Structured versus unstructured activities

In any programme involving young people, the question always arises as to how much structure there should be: in other words, the extent to which the activities should be supervised and controlled by the adult sponsors. Since most out-of-school scientific activities have an adult sponsor, this implies that the sponsor is responsible for the proper conduct of the activities. Here, 'proper' means ensuring that the students are involved in worthwhile activities and are not wasting their time, and encouraging them to do what they are supposed to do, with a proper regard for safety or for the welfare of animals, for example. If out-of-school activities are excessively controlled, on the other hand, they lose one of their greatest appeals – the 'fun' aspect. If there are too many rules and regulations, students will not enjoy the activities and may drop out. Classes are very important, but out-of-school activities should not be run like the classroom if they are to have any degree of success. Out-of-school activities must have a strong element of self-discipline. If students are really interested in what they are doing and want to achieve, they will discipline themselves.

In the last analysis, it is up to the adult sponsor to determine how much supervision is required for a particular group under different circumstances. Supervision will not be the same on a field trip, where there might be dangerous snakes, and at a club meeting of older students. The less supervision the better, but only if it is not needed.

Competitive versus non-competitive activities

Some people believe in having a certain number of competitive out-of-school scientific activities. Others are against all competition. The reasons for having competitions include the following:

1. Students like competitions and contests and they are important in stimulating interest and encouraging participation in out-of-school scientific activities.
2. Contests are voluntary, and students who do not like them do not have to participate.
3. It is illogical not to have contests, as there are many contests in other areas of activity: sports, music, writing, and so on.
4. Contests provide an additional interest in out-of-school scientific activities for other students, parents and the public.
5. Competitive selection in the higher-level contests provides a basis for identifying talented students, in particular those with abilities passed over by academic selection.

There are also reasons for not having competitions:

1. The students who do not win feel disappointed and their interest drops.
2. The competitive element inherent in contests is psychologically bad for students.
3. Competition can become excessive, with too much pressure put on students.
4. The less able students are not interested in participating as they have no chance of winning.

Individual projects versus group projects

In practical work, projects may be carried out by individual students or by groups of students. Both approaches have their advantages and disadvantages.

Individual projects afford the student a wider range of choice in the selection of topics, since he can select what he wants to do without taking into account the interests of others. Individual projects are also more indicative of a student's knowledge of the subject and his creativity and initiative, as it is easier to evaluate an individual student's contribution to his own project than to a group project. Lastly, individual projects provide considerably more self-satisfaction.

Group projects often make it easier for a student to become involved in project work, in that he can do some part of the project but is not responsible for the entire activity. Thus, students who might not otherwise be involved in project work are participating as part of a team. Group projects often teach co-operation in complex tasks and in team participation, something that is increasingly important in science and in other parts of life today; they appeal to the 'team spirit' in some students, motivating them in a way similar to team activities in sport.

Exhibitions versus seminars

Exhibiting at a science fair and reading a paper at a seminar are two ways in which students can communicate the results of their work. At a science fair, a student presents an exhibit summarizing his research, supports it with a verbal presentation and replies to questions. Reading a paper at a seminar involves an oral presentation followed by a question-and-answer session. Some people regard the latter method as superior, perhaps because it is closer to the traditional presentation by adult scientists at scientific meetings.

The main criticism levelled at science fairs is that undue emphasis is placed on judging the exhibit itself rather than on the research work it presents. The fault lies in the judging, however, not in the form of competition per se. Judging criteria should make it clear that it is the research project that is being judged, not whether an exhibit is spectacular or not. For this reason, the verbal presentation and the answers given to questions are essential elements in judging a science fair.

The main problem with seminars is that there is often little time for questions and answers; this means that the students receive little or no criticism of their research.

The involvement of youth not at school

Out-of-school scientific activities, as they are now constituted in many countries, are essentially for students at school. This leaves out a large number of young people who, for whatever reason, have left school or never attended school. Thus this group is missing both the learning derived from attending school, and the learning and other benefits to be derived from participation in out-of-school scientific activities.

Many young people do not attend school, but would like to participate in out-of-school scientific activities and would benefit from doing so; to date, little has been done to meet their needs, owing in part to the lack of adult sponsors, funds, space and equipment.

Animal experimentation

A basic philosophical problem in out-of-school scientific activities is whether students should be allowed to use animals (usually meaning vertebrate animals) in their research. This research may involve experiments which can cause discomfort, pain or even death to the animals.

One common view is that students should carry out no animal experiments whatsoever, under whatever circumstances. This position is usually supported by people who are against experiments with animals in scientific research, and philosophical, moral and religious reasons are given.

The opposite position supports such experiments, providing they are carried out under qualified supervision. This is the position taken by most people who support experiments with animals in scientific research. Where there are laws prohibiting students from doing experiments with animals, of course, the question does not arise.

The use of Protista and other invertebrates is to be encouraged for most research involving animals. It should be emphasized, however, that certain forms of investigation can be done only with vertebrates. Thus students who are prevented from using vertebrates are effectively prevented from doing advanced research, and this may lessen their interest in the biological sciences both at school and as a career.

Safety

Safety can be a problem in the school laboratory, and in a scientific institution. It can also be a problem in science contests, during demonstrations, on field trips and in a variety of other situations. Possible dangers include fire, explosions, radiation, electricity, cuts, laser light, poisons (either ingested or on the skin), viruses, bacteria, drugs and many others.

Teachers and club sponsors should set patterns and procedures for developing safety habits among students. These should be carried out as a regular part of the activities, and backed up by frequent reminders. Students who are engaged in out-of-school scientific activities must learn to think of safety and to consider the consequences of their actions in all aspects of their work. The need for basic rules, or procedures of a general nature, should be emphasized after giving specific information on the safety measures required by the particular activity. The basic rules should include the following:

Maintain a healthy respect for all scientific equipment and materials; know how they should be used; never put them to uses for which they were not intended.

Obtain full information on the characteristics and the safety precautions necessary when using or handling chemical substances, gases under pressure, radio-active materials, vacuum tubes, X-rays, ultra-violet sources, high voltage electrical equipment, bacterial cultures, diseased animal tissues, toxic plants and poisonous animals.

Make a safety check as a regular part of all laboratory activity where safety might be a problem.

Never use a laboratory as a place to play jokes or games.

Never experiment blindly 'to see what will happen'.

Obtain proper instructions and training before using any kind of equipment or laboratory glassware.

Learn and practise orderliness and cleanliness in the laboratory.

Demands on student time

Students are often deluged with extraordinary demands on their time, making participation and involvement in out-of-school scientific activities strictly a matter of priorities. The demands on their time come from several sources, both academic and non-academic. The pressures of the academic schedule may be such that students cannot or will not participate in out-of-school scientific activities, or, if they do, they may not have sufficient time to take full advantage of the activities involved. In the years immediately before university entrance in particular, the demands of preparing for examinations may preclude any out-of-school interests, scientific or otherwise. In countries where academic competition is not great, students may be extensively involved in out-of-school scientific activities, especially in independent research, producing remarkably advanced projects in science and mathematics.

Out-of-school scientific activities are in competition with non-academic pressures, such as amusements (television, radio, reading, games, sports, social events), other out-of-school activities (language clubs, drama, orchestra, class politics, etc.), and work (i.e. part-time work to earn spending money).

Teacher sponsors

Most out-of-school scientific activities will be sponsored by teachers and, as the demands of sponsorship are time-consuming, with little material compensation, the duty is unappealing to many. Most teachers are already very busy, and the demands of their work and their home life may prevent them from volunteering. Perhaps part of the reason also comes from a lack of understanding as to the value of out-of-school activities. Most teachers do not hear much about such activities during their training period, and so are uninformed and unenthusiastic.

Another problem is the frequent need for the sponsor to assume the prime responsibility for the activity's success. This means not only administrative duties, but also recruiting students and finding activities that will attract and interest them. This is a difficult and uncertain responsibility, and, for this reason, many teachers do not want to become involved.

Science advisers

Scientists can make important contributions to out-of-school scientific activities through acting as advisers on student research, judging at science fairs and other contests, giving lectures to students, conducting seminars and acting as hosts to students visiting their laboratories.

In most countries, however, there always seem to be too few willing specialists for the interested students. There are various reasons for this. Scientists are often unaware of the value of out-of-school scientific activities; some even feel it is beneath their dignity to work with young people – they see themselves as far too important to be involved and fear that other scientists might not respect them if they were. Again, students' research activities can cause special problems. To introduce one or more students into a laboratory may be very disruptive, both because of the need to supervise them and because their presence can slow down the laboratory routine. Their research activities may add to costs, and the laboratory may not feel it can spare the funds. Moreover, scientists may feel that students cannot do good enough research to be worth the effort.

Despite these problems, scientists who do work with students often become very enthusiastic and willing to do it again. Thus with many scientists, the major difficulty seems to be to secure their participation the first time. After that, they can usually be recruited again.

Support for activities

Adult sponsors of out-of-school scientific activities inevitably find that they need chemicals, paper, furniture, microscopes, travel money, magazines, and so on. This is even more true in the case of an activity which is successful and expanding. School funds are inevitably tight, or non-existent, or the activity may not rate high enough on the priority list to qualify for more funds.

Whatever the reason, out-of-school scientific activities are always in need of something. Even a simple activity like a paper plane contest needs paper; a science fair will need space, tables to hold exhibits, signs, and so on; a research project will require equipment, space and materials.

In some cases, the activity may be restricted or eliminated simply because the available support is not possible. In many cases, however, solicitations by the adult sponsor and/or the students may provide what is needed through fund-raising activities. These can include soliciting financial donations, obtaining required items from other sources or holding an auction or fund-raising event which charges an entrance fee. Some of the necessary items may be donated. For example, scientific laboratories may donate equipment, furniture and other materials. Commercial and industrial organizations may also be able to help.

8. JETS of Zambia – a case study

The JETS (Junior Engineers, Technicians and Scientists) organization of Zambia has, since 1968, been responsible for the promotion and popularization of science and technology among youth in Zambia. It has its own secretariat, headed by a national executive secretary – called the JETS Secretary – assigned by the Ministry of Education, operating from the School of Engineering at the University of Zambia. A high-powered committee, representing such education authorities as the Ministry of Education, the teacher-training colleges, the teacher associations, the National Commission for Unesco, the University of Zambia and the National Council for Scientific Research and Industry, constitutes the JETS Advisory Committee. It meets as often as required to criticize and advise, and to approve the policies of the JETS programme. The Dean of the School of Engineering (as national JETS co-ordinator) chairs this Advisory Committee. In carrying out its basic objective, JETS liaises with national and international agencies connected with the popularization of science and science education. The aims of JETS are: to popularize science and technology among secondary school students; to help secondary school students acquire a better foundation in order to meet the increasing demands of engineering and technical institutes; to give youth an opportunity to learn and apply scientific principles in the design and construction of technical projects; to help students learn how to do research work leading to the preparation and presentation of technical reports; to help students in discovering and appraising their own abilities, aptitudes and interests; to provide a preview of engineering, technology and other sciences and some acquaintance with people working in these fields; and to make youth aware of opportunities for careers in engineering, the sciences and related technical fields in the public and private sectors of the country's commercial and industrial life.

These aims are fulfilled by: creating science clubs at secondary schools; organizing science fairs at school, regional and national levels; organizing quizzes at school, regional and national levels; disseminating scientific and technical information; supplying popular science literature; promoting public lectures by prominent experts; providing career guidance in science and technology; organizing workshop courses in as many related fields as possible for club advisers and laboratory technicians and for selected pupils; organizing special projects such as surveys in various aspects of scientific interest; providing technical and academic assistance for students' projects, and giving financial assistance to major projects; providing technical assistance in the maintenance and repair of school laboratory/visual aid equipment; and producing laboratory apparatus, including electrical measuring instruments, through the JETS Production Technology Programme.

Science clubs

Organizing a science club, which is essentially an out-of-school or extra-curricular activity of students, is an essential factor in the popularization programme. There must be direct access to all schools, and co-ordination with the Ministry of Education is therefore absolutely essential. In the case of an existing club, organization will mainly be a matter of ensuring a continuity of activities. But should no club exist, one must be initiated and formed. This begins with a visit from the JETS Secretary or the regional organizer to the school concerned and a meeting with members of the science department and a few pupils. A talk is given on what a science is all about and where it could lead the students. A few examples of what is happening elsewhere can arouse the pupils' interest.

The success or failure of science clubs depends on various factors. The co-operation of the school staff must be solicited. Their enthusiasm depends on the amount of energy and interest that a teacher with a heavy work-load manages to raise at the end of a normal working day. In Zambia, the organization of club activities forms part of the duties of the head of the school science department. The students work on many different types of project: in biology, chemistry, mathematics, physics, electronics, and so on. The adviser alone cannot cover all these varied fields; they require the assistance of other teachers in the school.

There are many ways in which clubs can be funded: students can make regular monthly contributions, the school can make provision from its special fund reserved for such activities, the club may seek assistance from the local community, especially from commercial firms, or it could receive help from the JETS organization itself. Fund-raising film shows and raffles could also be organized.

Fairs

When the students have undertaken a sufficient number of projects over a certain period (usually a year), they are given the opportunity to display and explain their work to their colleagues and to the community in general. They may participate in their local community fairs, such as the agricultural show. The first major step in this development, however, is the organization of the school fair. This is usually held in conjunction with some important function at the school, such as School Day, the Open Day, the Speech Day, and so on; in some cases, the fair is a separate function in itself. The displays of project work are arranged in some classified order, along with whatever other exhibitions the science department, the mathematics department or any other department may collectively display. The public will be invited. Local and other dignitaries will visit the function and the students will have their first taste of an organized public science exhibition. The projects will be assessed by an impartial group of judges and prizes may be awarded to the winning projects. JETS supplies certificates to all participating students and awards books to winning students. Projects are classified under the titles of Physical Science, Biological Science, Mathematical Projects and Paper Presentation. Both Senior and Junior Sections are displayed and, since 1978, a section has been devoted to projects related to village development.

A regional fair is essentially a competition between schools of a certain region. For convenience, Zambia is divided into eleven 'JETS Regions', with an average of eleven secondary schools per region. Prize-winning projects from the school fairs compete at these fairs, and students who win first prizes in the various categories of regional fairs qualify for participation in the National JETS Fair.

The organization of the regional fairs begins as early as January each year, so as to lead up to the National Fair that takes place during August/September. The first step is to identify organizers and venues for the fairs. Teacher organizations in the sciences and mathematics are asked to submit the names of people who would be prepared to undertake the work involved in a voluntary capacity. In areas where teacher organizations do not function, the JETS Secretary requests nominations from known teachers in the field and seeks the co-operation of the Chief Education Officers. Their nominees are then confirmed as organizers. Such an exercise formally guarantees co-operation and support from the Regional Education Office.

Venues for the regional fairs are essentially of two types. In an area such as Lusaka, where almost all schools are within a few hours of each other, a venue with only exhibition and catering facilities will be necessary. In all other cases, in addition to an exhibition facility, accommodation for the hundreds of participants – students and their teachers – who may have to travel hundreds of miles to reach the venue must be available.

The organizer will normally (though not necessarily) be a teacher from the host institution and will have the full support of the head of the institution where the fair is held. The organizer seeks the assistance of the Chief Education Officer of the province in forming an organizing committee. The Regional Inspector of Schools is usually the key figure in the organizing committee. Prominent individuals in the community (selected for their academic, professional or social standing), heads of institutions, former organizers, teachers from schools and, indeed, any person who could render useful service are invited to form the organizing committee. This committee is responsible for: fixing dates and confirming the venue; inviting the chief guest; arranging accommodation for participating pupils and teachers; organizing the catering facilities; publicity, information, decor and protocol; prizes to be awarded; arrangement of projects; fund raising; selecting and briefing adjudicators; organizing the item selection panel for the regional quiz and the appointment of the quiz-master and his team; conducting the quiz; and so on.

The regional organizer co-ordinates the work of various sub-committees appointed to plan and execute these tasks. They meet as often as required and their efforts culminate in the regional fair. On average, a regional fair will display 100 projects and bring together 250 participants.

JETS provides a reasonable cash advance well before the date of the fair. In regions which are far from the capital, the grant would be sufficient to meet all expenses related to the fair. In areas where regional fairs are well organized, supplementary finances are sought from the local community.

JETS assigns a very senior member of the University of Zambia and/or the Ministry of Education to represent it officially at these regional fairs. This ensures a high national standard of adjudication of projects. JETS provides special certificates and invites the first-prize projects and special projects to the National Function.

The National JETS Fair and Quiz

The National JETS Fair is organized purely by the JETS Secretary. Accommodation is provided for all invited participants and their advisers, and technical staff are provided to assist them. It is only by winning a first prize at a school and a regional fair that one qualifies for an invitation to the National Fair. This function generally runs over a period of four days and the chief guest is usually a very high ranking national dignitary. Adjudicators are selected from an array of specialists from the educational sector, the National Council for

Scientific Research, industry, and so on. Each section is usually judged by three adjudicators.

The JETS Quiz is an activity devised to encourage further interest in science and mathematics among young people Unlike all other systems, items for the quiz originate from the students themselves. The teacher's role is that of item analyst, organizer and quiz-master – not item writer. The items test knowledge, understanding, relations and application in the various disciplines of science and mathematics. The items written by students are reviewed by teachers, checked for obvious technical errors, classified according to a test specification and arranged in ascending order, from easy to difficult, in each respective discipline. The teacher then conducts the school quiz. This is a very interesting activity in the school curriculum; it creates considerable interest in the various subjects involved and provides tremendous fun and entertainment as a school activity. It is organized on a competitive weekend, class or house basis.

Dissemination of information

For students to carry out project work and have a proper, up-to-date understanding of science and technology, it is imperative that reading material be made available to them. There is, unfortunately, a dearth of such literature at present, although JETS does its best to provide such material. Popular science magazines such as *Science Digest* (New York) and *Computers & Electronics* (New York) are supplied free to every school. Articles of interest from various international science magazines are circulated. In addition, a magazine, *JETS of Zambia,* was published until 1974. Aimed at secondary school students, it was used to circulate articles of interest, including local news, project suggestions, career information, competitions, and so on. This magazine, symbol of the JETS Clubs, was provided free to schools until 1974, when it had to be discontinued owing to the rise in printing costs and lack of funds. A cheaper cyclostyled version, *JETS News,* was then published, and a newsletter, *JETS Digest,* has also been circulated.

Lectures by experts in the field of science and technology at the school, regional and group levels provide a favoured means of disseminating information. Organized group visits to places of scientific interest, and industrial installations, also contribute towards this end. JETS have yet to utilize the mass media for its popularization programmes. However, other science programmes are broadcast over the television and radio networks.

Workshops

It is not possible for a single teacher – the club adviser – to be well versed in all aspects of science. His colleagues may be able to help him, but it is sometimes extremely difficult to assist certain students in their project work. Lack of know-how and skill, lack of apparatus and lack of literature are some of the contributing factors. In an attempt to alleviate this situation, the JETS workshops organize courses for teachers and selected students in many disciplines such as woodwork, metalwork, photography, electronics and radio, laboratory management, production of visual aids, repair and maintenance of laboratory equipment, and so on. These are conducted at regional and national levels at regular intervals. Selected participants meet at arranged venues, where facilities, tools and instructors are provided. The tools used during the courses are generally donated to the participants' respective science clubs. This support is expensive as accommodation, meals and the cost of tools and travelling all have to be met. A follow-up on the correct usage of the tools provided is also essential. Unfortunately, JETS has not been very successful in this exercise owing to limitations of staffing and travel facilities. Shortage of science equipment in schools is a very common feature. As a result, workshops have been organized for the manufacture of simple, low-cost science equipment and for the repair and maintenance of electrical instruments. Under this Zamkit Programme, electrical apparatus such as ammeters, voltmeters and power packs have been made.

As a result of the interest shown by clubs or teacher assocations, three special camps have been organized: a geothermal survey of an area in Luapula Province; a camp related to the manufacture of local salt; and a camp related to the survey of bilharzia in a particular area.

JETS activities in the primary school sector

JETS activities were introduced into the primary school sector as early as 1973. Since Zambia has 3,760 primary schools (compared with 121 secondary schools), it is clearly impossible for the present staff of the JETS Secretariat to initiate and supervise individual clubs in every one of these schools. Primary schools within the area of a given secondary school use the secondary school as a nucleus. They are encouraged to seek the assistance of the secondary school science teachers with projects, particularly with the improvisation of teaching material.

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Appendix I

Specimen constitution of a science club

Constitution

Article I
Name

Section 1. The club should be known as the ______________________ Science Club.

Article II
Aims

Section 1. The aims of the club shall be:
- (a) To increase our knowledge of science.
- (b) To learn specific skills in science.
- (c) To give service to our community and nation.
- (d) To understand the importance of science in our lives.
- (e) etc.

Article III
Members

Section 1. Any boy or girl interested in the aims of this club may apply for membership.

Section 2. Application for membership must be made in writing to the secretary, who shall investigate the eligibility of the candidate and report at the next regular meeting.

Section 3. Any individual who meets the eligibility requirements set up by the sponsor or by the school administration may then become a member.

Section 4. Members must attend meetings regularly. Three consecutive absences without satisfactory reason will be considered cause for dismissal from the club.

Section 5. At the beginning of the school year, the membership roll shall be revised to include only active members who are in good standing.

Article IV
Officers

Section 1. The officers of the club shall be as follows: president, vice-president, secretary, treasurer, librarian, reporter.
Section 2. The election of officers shall be by majority vote and shall take place at the first regular meeting of each school term.
Section 3. Officers may resign by giving written notice to the secretary and to the club sponsor.
Section 4. Elections may be held whenever an office is declared vacant.
Section 5. The duties of the president, vice-president, secretary, treasurer, librarian and reporter shall be those which are usually performed by such officers.
Section 6. The vice-president shall supervise the presentation of the science programmes at the meetings.
Section 7. The librarian shall be responsible for the storing and care of all supplies, equipment and apparatus possessed by the club.
Section 8. The reporter shall handle all publicity for the club.

Article V
Meetings

Section 1. Regular meetings shall be held on
of each week, during the school session. Unless otherwise announced, all meetings will be held at ______________________.
Section 2. Special meetings may be called by the president at any time.

Article VI
Dues

Section 1. Dues shall be ________ per term. Changes in dues may be voted by two-thirds of the active membership.
Section 2. Money acquired by this club shall be spent for club needs.
Section 3. All expenditures must receive the approval of the club sponsor.

Article VII
Programme

Section 1. The business portion of the regular meetings shall not be longer than 20 minutes.
Section 2. Programmes of the regular meeting shall not last longer than 2 hours.
Section 3. Programmes shall be planned for all regular meetings by a committee appointed by the president.

Article VIII
Amendments

Section 1. This constitution may be amended by a three-quarters vote of all members.

Appendix II

Junior science academies – examples from the USSR

The Junior Academy of Science (JAS), the 'Pathfinder' in the province of Crimea, has been in operation for nearly twenty years. A model charter and statute governing the work of junior science academies has been developed. This clearly sets out the objectives and tasks of the JAS, the rights and obligations of its members, the organizational structure of the academy, the rules for admission and maintenance of membership on the basis of performance, and the principal forms of science work by student members. All the activities of each JAS are based on the principle of self-management. The charter and organizational structure of the 'Pathfinder' academy codify and reflect the active role of the pupils themselves as the decisive constituency of the junior academy. Teacher and pupil thus become colleagues in a very real sense. The presidency of a JAS is accorded to a major scientist, while its two vice-presidents are school students. The annual general meetings of a JAS (these meetings constitute the principal governing body of each junior academy) are an occasion when youngsters, enthusiastically and in a businesslike way, discuss and make decisions concerning all aspects of the work of the academy; they also select candidates for membership and elect full members. There are branches of the academy in all districts of the province of Crimea. Nearly 5,000 students in the senior grades attend lectures, seminars and annual practical workshops. Many of them embark on careers with their subject interest in the academy as a springboard. The junior academicians also meet together each year at special summer-camp sessions visited by leading scientists and prize-winners working in various fields of science and technology. The many years of experience of the Crimean JAS show that it is a body which not only deepens and extends the pupils' knowledge and vision, but also imbues them with the highest civic virtues and values. It is therefore appreciated both by the pupil members themselves and by scientists belonging to an older generation.

Considerable experience in work with school-age youngsters has likewise been built up by both public organizations and individual scientists in Siberia. From the very first year of its existence, the Siberian Branch of the USSR Academy of Sciences has been engaged in a fruitful effort to attract youngsters to science and deepen their understanding of it. This activity is guided by the Komsomol committees and Young Scientists' Councils of the Siberian Branch of the USSR Academy and by the Soviet District Committee of the Komsomol of the city of Novosibirsk.

The Presidium of the Siberian Branch of the USSR Academy of Sciences has operating under it a scientific centre on educational matters, one of whose tasks is to co-ordinate the work of young scientists and specialists among students. This body includes thirty-five scientists, of whom twenty hold the degree of Doctor of Sciences. Its members head various groups and commissions concerned with work among young people. The group on the use of computers in school is chaired by the chief of the information department of the Computing Centre of the Siberian Branch, while the commission on the scientific and technological advancement of young people works under the director of the young engineers' and technicians' club of the Siberian Branch.

The Komsomol organization and the Council of Young Scientists and Specialists of the Siberian Branch of the USSR Academy of Sciences are carrying forward a diversified effort to spread scientific and technological knowledge among schoolchildren. Their objectives include: offering a broad range of professional and occupational counselling services; raising the level of training received by secondary school students; and developing the scientific vision and research skills of youngsters. In fact, all councils of young scientists and specialists at the level of the various institutes of the Siberian Branch operate sections (commissions) concerned with work to benefit school-age young people.

Over 100 young scientists and specialists of this important scientific centre are guiding the work of sections and science circles in physics, mathematics, chemistry, computer science and other fields. The youngsters who take part in such groups do not simply acquire additional knowledge; they also play a direct role in the activities of the laboratories of institutions.

Moreover, young scientists of the Siberian Branch operate correspondence and winter course programmes for school-age youngsters of Siberia. Roughly 7,000 youngsters undergo training in the correspondence course programme with its five sections each year. The Novosibirsk State University also operates a school on Sunday for 800 students. The functions of young scientists working within each type of school involve the development of study plans and practical assignments for students, presenting lectures and guiding laboratory exercises. As a result, students have deepened their understanding of science, and their interest in a given field has been heightened – with better-founded career choice as a by-product.

Appendix III

Organization of a science and technology fair[1]

Stage I (15-12 months before)
10. Venue
11. Steering committee
12. Nature of fair
13. Fair manager, chairman and secretary of steering committee
14. Preliminary notification to schools
15. Budget
16. Dates
17. Logo

Stage II (12-9 months before)
20. Fair programme
21. Financial support
22. Officers' responsibilities
23. Invitations to possible exhibitors
24. Invited visitors
25. Booking of display screens, tables, etc.

Stage III (9-6 months before)
30. Pressure for more exhibitors
31. Go/No-go decision
32. Official opening
33. Exhibiting schools/institutions
34. Invitations for school visits

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[1] Adapted from the British Association for the Advancement of Science guide.

35. Reprographics – detailed programme
36. Publicity officers
37. Meeting with teachers from exhibiting schools
38. External fair signs
39. Competitions

Stage IV (6-3 months before)

40. Catering
41. Publicity
42. Helpers
43. Insurance, security and safety
44. Spare display materials
45. Badges
46. Reprographics
47. Invitations
48. Cover design

Stage V (check-list and run-up to fair)

50. Parking
51. Signs (external and internal)
52. Publications
53. Liaison with police and fire brigade
54. Meeting with teachers from exhibiting schools
55. Stewards
56. Meal tickets printed
57. Certificates for exhibitors
58. First aid post
59. Opening ceremony

Stages VI/VII (during fair)

60. Setting up
61. Technician help
62. Fair trail/quiz
63. Reception
64. Opening party
65. Display material
66. Meal tickets
67. Sales point
68. Evening/Saturday session
69. Fair closure
70. Private viewing for teachers

71. Exhibitors
72. Photographs

Stage VIII (after fair)
80. Thank-you letters
81. Accounts
82. Report

STAGE 1

10. Venue

The venue should preferably be an institution used to handling educational events and able to cope with large numbers. Fairs have been held in schools, colleges, universities, museums and art galleries.

Requires: Adequate parking facilities, flexible catering arrangements.
Technicians available and willing to assist before and during fair.
Large 'halls'.
Laboratories or services available.
Reprographics department (desirable).

11. Steering committee

It is necessary to create a balance between a committee of workable size and one with wide representation. Consider including industrialists, educational advisers (primary and science), representatives of Chambers of Commerce, staff of venue institution, museum staff, school-teachers (secondary and primary). Members should be people with an interest in the fair and willing to work. If possible, some members with experience of a previous fair are desirable.

12. Nature of fair

Are primary, secondary and tertiary age groups to be included?
Is there to be a special emphasis or theme?
What will be the general form of the fair?
Will there be any sort of competitive element within, or associated with, the fair?

13. Fair manager, chairman and secretary of steering committee

Fair manager – someone preferably belonging to venue institution (if possible as part of commitment) with secretarial help.

Chairman – contact person with influence, e.g. civic dignitary or official, head of venue institution, someone recently retired with time and influence.

Secretary – preferably also belonging to venue institution to share work-load with manager.

14. Preliminary notification to schools

A preliminary notice of of the science and technology fair with dates and venue should be sent direct to schools.

15. Budget

Try to foresee and list all possible items of expenditure, whether the cost will have to be met in cash or in kind. A full checklist is given on pages 127–8.

16. Dates

The dates should be fixed to ensure maximum participation by schools and best co-operation from venue institution.

17. Logo

A logo with emphasis on science and technology is helpful for notepaper, publicity, posters, etc.

STAGE II

20. Fair programme

What, if anything, is to be included in the fair in addition to exhibits from schools?

Consider: Lecture programme.
Film show(s).
Careers convention.
Industrial exhibitions.
Exhibits from institutions of higher education.
Hands-on displays, e.g. micro-computers.
Displays of leisure and hobby club activities.
Display of resource material for teachers.
Competitions: pre-set problems (e.g. best rubber-band powered vehicle) and/or unseen design-and-make problems.
Fair trail/quiz for visitors.

21. Financial support

Applications should be sent to: banks, local industries and commerce, education authorities.

22. Officers' responsibilities

At this stage, it is useful to draw up and distribute lists of responsibilities during the fair, e.g. who will be responsible for:

Liaison with exhibitors.
Supervision of visiting schools.
Publicity.
Signs.
Supervision of VIPs and ceremonial?

23. Invitations to possible exhibitors

Send invitations to all schools and colleges in area to participate. Arrange meetings with teachers for briefing for those new to fairs and feedback from those with experience.

24. Invited visitors

You will probably want to invite some visitors to attend the official opening and tour of fair, some to attend at other times.

Consider: Mayor.
Chairmen of Councils.
Directors of Education.
Governors.
Heads of schools.
Industrialists.
Heads of other large educational institutions.
Chairmen of professional institutions.
All branches of the media.

Also consider at this stage judges for any competitions you have decided to arrange and invite them.

25. Booking of display screens, tables, etc.

Make preliminary enquiries about screens available and booking where possible – transportation needs to be borne in mind. The availability of display screens can become a major problem.

STAGE III

30. Pressure for more exhibitors

Arrange visits (preferably by science fair manager or science adviser) to likely schools, to encourage their participation. Also arrange a meeting of the local teachers' group to encourage participation (using material from previous fairs for guidance).

31. Go/No-go decision

A definite decision is needed in the light of response from likely participants, financial sponsors, etc.

32. Official opening

Opener – local or national personality, e.g. mayor, member of parliament, government minister, government department official, television personality.

Opening ceremony: Decide on platform party, speakers.
Decide on form, timing of tour of exhibits, refreshments, meals, etc.

33. Exhibiting schools/institutions

Send a letter to exhibiting schools requesting details of requirements, e.g. display screens, tables, services (water – static or running; electricity; gas), use of video cassette players, visual aids, television, and special needs. State limitations, if any.

34. Invitations for school visits

Send a letter to all schools and colleges inviting them to visit. Ask them to specify numbers, and mode of transport. Where appropriate, ask for requests for lecture tickets and competition entries. A reminder letter will probably by needed later.

35. Reprographics – detailed programme

Liaise with department or outside printers and confirm deadline dates for publication of programmes, brochures, meal tickets, questionnaires, worksheets, etc.

36. Publicity officers

Appoint: to push fair with local paper, radio and television.

37. Meeting with teachers from exhibiting schools

Issue invitation to teachers of exhibiting institutions to attend meeting at venue two months before fair to discuss arrangements, setting up and layout of display, meal arrangements supervision, booklet details and to visit display site.

Stress importance of good display (particularly to secondary schools).

Discuss transport of display material either out of funds or on the basis that schools make their own independent arrangements, asking for help if necessary.

Stress importance of gain to pupils in manning of displays and in having to explain and demonstrate their work.

38. External fair signs

Make request for traffic signs.

39. Competitions

Send details of pre-set competitions to schools. Decide on sealed-envelope competitions, and send notification of intent to schools with request for entries. Consider judges if not already decided on.

STAGE IV

40. Catering

Make arrangements regarding payment of meals for exhibitors, helpers and visitors if these are to be provided – ideally by issuing meal tickets and paying one bill from the institution.

41. Publicity

Arrange through all channels.

42. Helpers

The fair will require a number of helpers for parking and reception duties, to supervise exhibition rooms and the flow of visitors, to man a telephone, etc. Judges for competitions should be confirmed if this has not already been done.

43. Insurance, security and safety

Make arrangements for locking up of display areas when fair is closed, to protect valuable equipment brought by schools. Check insurance cover provision.

Consider appointing a safety officer.

44. Spare display materials

It is advisable to have a spare supply of display-board covering paper, blu-tack, masking tape, sellotape, drawing pins, etc.

45. Badges

Badges must be worn by exhibitors manning stands and supervisors. Official badges needed for identification of helpers.

46. Reprographics

Check progress.

47. Invitations

Formulate and send official visitor invitations for opening or official tour of fair – followed or preceded by refreshments, if possible provided by host institution.

Invitation cards can be produced on the offset machine.

48. Cover design

Invite schools to submit designs for a cover for fair booklet/programme, to be judged at committee meeting 1 month before fair (all submissions displayed at fair).

STAGE V

50. Parking

Organize the production of adequate direction signs for car and bus parking, beginning at entrances.

Arrange for a system of runners between bus park and reception.

Signs external to venue need to be done.

51. Signs (external and internal)

Picnic areas, route signs to be large and placed above the heads of the crowds (try to design route which avoids congestion).

52. Publications

(a) Programme and map of fair

This can be done just before the fair and kept to one A4 sheet if produced internally; not possible if the programme is externally printed and has to include advertisements. If produced internally, the programme can be given away. A printed programme may need to be sold.

(b) Resource booklet (not essential but useful)
This consists of write-ups of all project work displayed, forming an ideas book for teachers, etc. All details from schools should be received 3 weeks before fair (deadline depends on reprographic capabilities). All material should be run off 1 week before fair to allow for collating. For sale to schools/teachers, etc.

53. Liaison with police and fire brigade
Discuss arrangements for traffic, security and safety.

54. Meeting with teachers from exhibiting schools
This should be arranged now if it has not been done earlier (see 37).

55. Stewards
Have adequate numbers of helpers at all locations of fair, allowing for breaks after 90 minutes. Useful to have reserves. Stewards can be from host institution.

56. Meal tickets printed
Make sure that these are produced (see 66).

57. Certificates for exhibitors
Science and technology fair certificates are desirable. Order required number from printers.

58. First aid post

59. Opening ceremony
Useful to include refreshment arrangements in invitation, e.g. 'to take tea afterwards'. Need to consider platform layout and any flower arrangement, etc. Also send invitations to teachers and pupils of participating schools, teachers from schools with prize winners (e.g. booklet cover winners) and parents (especially if young winners), head-teachers and representatives from sponsoring firms.

STAGES VI/VII

60. Setting up
Allow at least one whole day for this (a weekend would be ideal):
Allow at least one whole day for this (a weekend would be ideal): Allow at least one whole day for this (a weekend would be ideal): Allow at least one whole day for this (a weekend would be ideal): Allow at least one whole day for this (a weekend would be ideal): Allow at least one whole day for this (a weekend would be ideal): Allow at least one whole day for this (a weekend would be ideal): Allow at least one whole day for this (a weekend would be ideal): Allow at least one whole day for this (a weekend would be ideal): Allow at least one whole day for this (a weekend would be ideal):

(b) Plenty of helpers to assist exhibitors to set up.
(c) Manager and committee chairman to be free to deal with problems.

61. Technician help
Technicians should be available for setting up and during fair to help/advise on use of facilities.

62. Fair trail/quiz
Can only be prepared when exhibits set up, so ask teacher/tutor to do.

63. Reception
Teacher representative reports to reception desk and is given programmes and fair trail/quiz worksheets (with teachers' answers).
Another option is for schools to come at allocated times.

64. Opening party
Need escorting on tour of fair.

65. Display material
Promotion or display material can be provided centrally by professional organizations.

66. Meal tickets
To be collected by exhibitors each day (different colour for each day, with date and token value).

67. Sales point
To sell programmes (if necessary) and resource booklets.

68. Evening/Saturday session
Useful for parents and others to view 'at leisure' – exhibitors must be present.

69. Fair closure
Stipulate a time before which exhibits cannot be dismantled. Have plenty of 'rubbish' bags available.

70. Private viewing for teachers (worth considering)
Arrange times when teachers can view fair privately (with hospitality), so that they might be encouraged to participate in future fairs and might also be

prepared to mount micro-fairs in their own schools to encourage science (of particular interest to primary school teachers).

71. Exhibitors

Provide meal tickets for exhibitors each day – perhaps allowing a maximum of three per school (one teacher and two pupils).

Provide orange drinks for all exhibitors throughout day in a quiet room (allocated for their use).

72. Photographs

Take photographic record of all exhibits, to be sent afterwards to each school with certificate.

STAGE VIII

80. Thank-you letters

Letters should be sent to appropriate helpers and guests and to exhibiting schools. Ask for comments on the fair and ideas for the future.

81. Accounts

Pay all outstanding bills as soon as possible, draw up the accounts and have them audited.

82. Report

Prepare a report while the fair is fresh in the mind. Reflect on the problems as well as the successes and consider any follow-up and lessons for the future that might be indicated. Reports should go to the steering committee and to sponsors.

Possible items of expenditure

Hire of accommodation (halls/laboratories, etc.)
Hire of equipment (e.g. projectors)
Costs of caretaker/technician/projectionist
Hire/transport of display stands
Travel – participants/exhibitors/exhibits
Artwork
Reprographics – publicity/programmes/invitations/tickets, etc.
Advertising
Meals/refreshments – participants/helpers/stewards/judges

Secretarial help
Telephone
Postage
Stationery
Honoraria – e.g. fair manager/secretary
Speakers' expenses
Hospitality
Planning committee expenses
Hire of films
Sundry display materials – card/blu-tack/pins,etc.
Insurance
Badges/certificates
First aid
Signposting
Prizes

Appendix IV

Research and project work

Examples from India

1. *Exploration of the neighbourhood:*
   Study the environment, flora and fauna.
   Study industries, agricultural and horticultural farms.
   Study a railway engine, railway track and traffic system.
   Study airports, traffic control system, parts of an aeroplane.
   Study road transport, parts of a bus engine, operation, control, maintenance problems.
   Study pollution problems.
   Study problems of sanitation, sewerage, disposal.
   Study health problems, common diseases, causes of occurrence, prevention, cure, studies during typical seasons such as monsoon, hot summer.
   Study the water-table, its rise and fall with seasons.
   Study the nutritional value of foods.
   Study the efficiency of a domestic solar heater.

2. *Scientific investigations:*
   Study the pH of local fruit and vegetables and its effect on enzyme action.
   Study the effect of common chemicals on the heartbeat of a frog.
   Estimate the rate of oxygen consumption by local fish.
   Study the effect of different colours of light on the germination of bajra seeds.
   Study the effect of common detergents on the growth of plants.
   Study the effect of alternating current on the amount of deposit on electrodes.

Study the effect of varying magnetic field on the growth of a plant.
Study water taken from a well, river, lake with respect to density, pH, dissolved substances, electrical conductivity.
Identify blood group of students in a class.
Detect the nature and extent of adulteration in milk.

3. *Environmental activities:*
Determine the growth rate of a plant by studying its leaf area growth.
Estimate and study plant and animal population in a particular area.
Determine the loss of water from a plant.
Study different types of pollution in an environment.
Study the effects of air pollution.
Study the effects of water pollution.
Study how fossils are formed.
Determine the effect of soil on the growth rate of plants.
Determine the effect of salinity on seed germination.
Determine the percentage of water in a sample of soil.
Determine soil particles and their sedimentation.
Determine the effect of depth of sowing on the growth rate of plants.

4. *Some of the exhibits in a recent National Science Exhibition:*
Demonstration of the details of various aspects of bees and bee-keeping.
Indigenous way of watering fields with the help of a reservoir and propeller suction pump.
Incubator for hatching eggs.
Use of paddy husk as fuel for non-polluting furnace.
Use of the water hyacinth (normally considered a weed).
Model of a device to detect increases in the quantity of marsh gas.
Device to detect noise pollution.
Recycling of waste water from factories.
Working model to demonstrate how heart attacks are caused.
Preparation of nutty gas from coconut.
Burner operated on diesel, petrol or kerosene gas.
Working model of a solar-energy-based grain drier.
Light-sensitive switching system for street lights.
Scheme for producing potable water in a village.
Electronic device which warns of a car approaching round a blind corner.
Hot-air paddy drier.
Thermos flask designed from bamboo sawdust and a glass bottle.
Model of an improved bullock cart.
Working model of a modified high-efficiency, manual grain-thresher.

Device for the detection of railway track faults.
Improved, electronically controlled incubator.
Demonstration of the use of the waste banana sheath for making pulp board.
Machine which gives change for currency notes.
Measuring the vertical distribution of ozone in the atmosphere.
Measuring conductivity in the atmosphere.

Examples from Chemistry Project Weeks, Northern Ireland (United Kingdom)

1. Preparation and application of colorants:
The project will involve the preparation of several colourants (pigments and dyes) and their application to various substrates. The colours of the samples will be measured and the results related to the chemical and physical nature of the colourants, the method of application, etc.

2. Separation of hydrogen isotopes by electrolysis and isotope exchange reactions:
Electrolysis of aqueous solutions results in their gradually becoming enriched in the heavier hydrogen isotope deuterium.

If the element palladium is used as the cathode during electrolysis, much of the hydrogen released can be absorbed by the metal. The ratio of hydrogen to deuterium in the gas absorbed during electrolysis can be determined from measurements with a mass spectrometer, and this ratio provides a measure of how far the electrolyte has become enriched in deuterium.

The catalytic activity of palladium electrodes for exchange of hydrogen and deuterium atoms discharged on their surfaces, with the hydrogen and deuterium atoms in the surrounding water molecules, can also be studied in conjunction.

3. A study of the co-ordination chemistry of some chelating ligands containing nitrogen donor atoms:
In this project, the preparation of new transition metal complexes of some bidentate ligands containing nitrogen donor atoms will be carried out. Properties (e.g. infrared and visible spectra) will be examined in order to assign the structures of the complexes.

4. Determining the stereochemistry of nickel complexes:
Several complex forming reactions will be undertaken, each of which leads to a Ni^{II} complex with a different stereochemistry: octahedral, tetrahedral or square

planar. The students will make magnetic and spectroscopic measurements on their compounds which, with the aid of data supplied, will enable them to assign each one to its proper stereochemical classification.

Examples of topics for project work from Latin America

The effect of light on plant pigments.
The effect of pesticides on animals.
The development of protozoa in water.
The effect of heat on the dissolution of substances.
The presence of atmospheric contamination at various points.
Testing of Mendelian laws by using drosophila.
Electricity production.
Density variation in substances and its importance.
The effect of water in erosion.
The production of acids and bases.
The nutritive value of foods.
How a biogas/methane generator works.
Transformation of alternating current.
Construction of electric storage batteries.
Design of domestic solar energy systems.
The study of some electrically operated domestic appliances.
The utilization of optic fibres.
Devices to make use of energy from ocean tides and waves.
Utilization of energy from wind power.
Study of the cathode ray tube in television.
The rational utilization of urban wastes.
Remote control devices.
The photoelectric cell and its applications.
Domestic electric circuits.
How to prevent electric discharges.
Regulation of current in a circuit.
Transmission and receipt of signals.
Electromagnetic waves.
Microwaves.
Ultrasonic vibrations and their applications.
Applications of piezo-electricity.
The binary digital computer.
The community organization of bees.
The community organization of ants.
Experimental archaeology.

The working of different electric circuits.
Insects and their life cycle.
The harnessing of solar energy.
The relation between photosynthesis and respiration.
Differences and similarities between animal and vegetal cells.
Industrial contamination of water.
Climatic variations occurring in the district.
The geological history of the region.
The division of farming and livestock development by zones: possibilities of industrial application.
Study of nitrification and denitrification of the soil.
The Poisson law in nature.
Harmony of quadratic curves.
Clock-making (sand, water, pendulum movements, etc.).
Colouring agents: are they coloured substances?
Water purification.
Traditional home-craft production techniques.
Alarm systems.
Typology of prehistoric artefacts.
Importance to life of the phenomenon of freezing in water.
The influence of artificial light in a beehive.
Reconstruction of prehistoric forms of life.
Investigations concerning Drosophila Melanogaster.
Mathematical interpretation of the annual temperature variation.
Enzymatic reactions.
The carbon dioxide-powered motor.
Spores and plant transpiration.
Mathematical models and natural phenomena.
Electricity in motor vehicles.
Topography of the district.
Problems in the use of insecticides.
Hydroelectric energy.
Electric storage batteries and accumulators.

Appendix V

Olympiads – examples of questions from recent international chemistry and physics olympiads[1]

Physics, theory

QUESTION: Suppose that you are standing in a flat desert. At some distance away you see what appears to be water. When you approach the 'water', it seems to recede so that the distance to the 'water' is always constant. Explain this phenomenon.

ANSWER: Total reflection of sky in hot air layer which implies that $\beta = 90^\circ$ and thus

$$n_A \cdot \sin \alpha = n_B$$

Physics, experimental

QUESTION (Instructions to students): Describe briefly how to perform the experiment. Make clear in your report the procedure you have adopted. A formal mathematical calculation of errors is not required, but an estimate should be made.

Note: The time allocated for the experiment is 1 hr 50 min.

The spectrum of a neon lamp contains a number of spectral lines in the yellow-orange-red region. Determine the wavelength of the yellow line with the greatest intensity, which lies at the short wavelength end of the yellow part of the spectrum. Make an estimate of the accuracy of your wavelength determination.

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[1] The examples given are adapted from the *Proceedings of the 15th International Physics Olympiad*, Sigtuna (Sweden), 1984, and the *Report of the 16th International Chemistry Olympiad*, Frankfurt/Main, 1984.

Apparatus: neon lamp that is connected to 220 V AC; laser with unknown wavelength; grating; transparent scale 1 mm long (at the centre of a circle) divided into 100 equal parts; 1 m rule; retort stand with clamp.

NB: You may *not* assume a value for the wavelength of the laser light.

SOLUTION: When light from the laser is allowed to fall on the transparent scale a diffraction pattern is observed on the wall and the wavelength of the laser can be determined.

The experiment is then repeated with the grating instead of the scale and from the new diffraction pattern the grid constant can be calculated.

The neon lamp is then observed directly through the grid. By observing the position of the first order spectra in the room and then making suitable measurements with the ruler, the diffraction angle can be found, and from it the actual wavelength can be calculated.

Chemistry, theory

QUESTION: The elements strontium and rubidium have the following isotope composition:

Strontium: 0.56% ^{84}Sr; 9.86 % ^{86}Sr; 7.00 % ^{87}Sr; 82.58 % ^{88}Sr (these isotopes are all stable)

Rubidium: 72.17 % ^{85}Rb (stable); 27.83 % ^{87}Rb (radioactive; $t_{1/2} = 4.7 \times 10^{10}$ years)

The radioactive decay of ^{87}Rb leads to ^{87}Sr.

In Greenland one finds a gneiss (= silicate mineral) containing both strontium and rubidium.

(a) What is the equation describing the formation of ^{87}Sr from ^{87}Rb as a function of time?

(b) Assume that the isotope ratio $^{87}\mathrm{Sr}/^{86}\mathrm{Sr}$ (as determined by mass spectrometry) and the isotope ratio $^{87}\mathrm{Rb}/^{86}\mathrm{Sr}$ are known for the gneiss. What is the mathematical relationship with which one can calculate the age of the gneiss?

SOLUTION: (a) For the decay of the ^{87}Rb:

$$^{87}\mathrm{Rb} = {}^{87}\mathrm{Rb}_o e^{-\lambda . t}$$

The symbol ^{87}Rb stands for the number of atoms of this nuclide.

Consequently, one obtains for the formation of ^{87}Sr from ^{87}Rb:

$$^{87}\mathrm{Sr} = {}^{87}\mathrm{Rb}_o - {}^{87}\mathrm{Rb} = {}^{87}\mathrm{Rb}.e^{\lambda.t} - {}^{87}\mathrm{Rb} = {}^{87}\mathrm{Rb}\,(e^{\lambda.t} - 1) \qquad \text{(a)}$$

(b) The formation of the radiogenic ^{87}Sr follows equation (a).

One has to take into account that at time $t = 0$, when the mineral was formed, there was some non-radiogenic strontium in it already:

$$^{87}\mathrm{Sr} = ({}^{87}\mathrm{Sr})_o + {}^{87}\mathrm{Rb}\,(e^{\lambda.t} - 1) \qquad \text{(b)}$$

The isotope ratio $^{87}Sr/^{86}Sr$ is described by:

$$^{87}\mathrm{Sr}/^{86}\mathrm{Sr} = ({}^{87}\mathrm{Sr}/^{86}\mathrm{Sr})_o + {}^{87}\mathrm{Rb}/^{86}\mathrm{Sr}\,(e^{\lambda.t} - 1) \qquad \text{(c)}$$

The isotope ratio $(^{87}Sr/^{86}Sr)_o$ follows from the isotope composition of strontium. The time t in equation (c) corresponds to the age of the gneiss.

Chemistry, experimental

Determination of the phosphoric acid concentration in a cola drink

Apparatus: 500 ml round-bottomed flask with stirrer; magnetic stirrer; reflux condenser; heating mantle; water bath; thermometer; 100 ml pipette and 50 ml pipette; filtration apparatus; titration apparatus.

Chemicals: powdered activated charcoal; sodium hydroxide solution [NaOH] = 0.0500 mol l^{-1} (0.0500 mol dm^{-3}); buffer solutions.

Preparation of the sample: add the contents of a bottle of cola drink to the round-bottomed flask and stir for two or three minutes. Add 6.0 g activated charcoal. Heat the entire suspension under reflux for ten minutes.

Note: The glass joints of the reflux condenser must *not* be greased.

Remove the heating mantle and substitute an ice-water bath. After the sample has cooled to 20 °C, filter the mixture through a double-thickness fluted filter paper. The filtrate should be recycled several times.

Adjustment of the pH meter: the pH meter should be calibrated using the two buffer solutions. (The laboratory assistant will explain the use of the pH meter upon request.)

Titration: using the pH meter, titrate 150 ml of the prepared cola solution with sodium hydroxide solution (concentration = 0.0500 mol l^{-1}). The first equivalence point of the phosphoric acid is reached after about 6 ml of the sodium hydroxide has been added. The titration should be continued until more than 12 ml of sodium hydroxide solution have been added.

Note: Be sure to record your data as you perform the titration.

Results of the experiment:

(a) Draw the titration curve and determine the first equivalence point.
(b) Determine the pH of the cola drink after heating and cooling to 20 °C and the pH at the first equivalence point.
(c) Calculate the concentration of phosphoric acid in the cola drink. Show your calculation in full and the result in your report.

Interpretation:

(d) Describe and explain your observations during the titration.
(e) Is it possible that the activated charcoal could have influenced the results of your titration? Give reasons for your answers.

Appendix VI

Science field trips and science camps in British Columbia (Canada)

British Columbia: an overview

British Columbia has an area of 984,000 sq. km as shown on the flat surface of a map, but is is a land of mountains and, if the true area of all the mountain slopes were measured, the actual area would prove to be about 20 per cent greater. British Columbia is a maritime province and its many fiords produce a shore line of some 7,200 km. Approximately 2.4 million people populate this province, 90 per cent of them crowded into the south-west corner. Thus the population density of this corner is about the same as that of Singapore, whereas, for the northern half of the province, the density of population is about 0.03 person per square kilometre. This would imply two incentives for trips away from school: to explore the vast open spaces and to escape to areas of fewer inhabitants.

In British Columbia, the Ministry of Education and the seventy-five local school districts give overwhelming support (not always financial) to programmes of out-of-classroom education.

Field trips may be considered as single day trips away from the classroom or extended trips which involve spending at least one night away. They therefore necessarily involve plans for food and accommodation. Day trips may be to a beach, pond, park, alpine meadow, swamp, zoo, aquarium, planetarium, botanic garden, waterfowl refuge or local industry. These trips may come solely under the guidance, supervision and expertise of the classroom teacher or they may constitute a ready-made programme offered by the education officers employed by the institution to be visited.

Extended trips usually involve lengthy and often expensive travel as well as the need to consider food and lodging. These trips may be under the sole guidance and organization of the classroom teacher, but they frequently involve other degrees of expertise. They often include visits to environmental centres and school camps.

British Columbia's teachers are under no obligation or limitations as to the number of field trips that they may arrange for their classes. Thus some classes may not have the opportunity for even one trip, whereas others may take several trips of considerable variety within a school year. When trips are authorized by a principal or a local school board, the teachers are fully covered by insurance and legal responsibility laws.

In the province, many trips centre on winter activities such as skiing, skating, snowshoeing, ice fishing or changes in plant and animal life related to the severe winter climate. Any one of these activities may be the main objective of the trip, or they may be incidental to some other major trip, event or topic of investigation. Extended trips may vary from two days to two weeks. Many teachers take advantage of the weekend before and after a school week to arrange a nine-day trip. The majority of the trips are of five days' duration. The distance travelled may vary from a few hundred metres to the plot next to the school yard, to several thousand kilometres to visit a series of mining operations or heritage villages. Methods of transportation also vary considerably. Hiking and back-packing, bicycles (with equipment transported by truck or van), private cars, mini buses, chartered buses, school buses (with part of the expense sometimes being borne by a local school board), chartered boats, ferries, canoes, trains and even aeroplanes, both private charter and scheduled commercial flights, are all utilized. The duration, destination and mode of travel are all the prerogative of the organizing teacher.

Accommodation is at campsites with a variety of degrees of facilities provided: hotels, motels, hostels, billets in private homes with the promise of reciprocal accommodation on an exchange at a later date, and on the floor of school gymnasia or staff rooms.

Places visited may include: mining operations, concentrator and smelter, fossil beds, forest operations, sawmills, pulp mills, veneer plants, nurseries, reafforestation sites, heritage villages, alpine meadows, streams, ponds, lakes, rivers, ecological reserves, Arctic tundra, marinas, wharves, ship loading and docking, fishing and fisheries operations, fish spawning beds, wildlife and conservation reserves, archeological sites, relics, various manufacturing plants and communities.

The number of field trips has increased dramatically over the last decade. About twelve years ago, the occasional teacher would take a class or group on an extended trip away from the classroom. These fortunate classes were usually from the upper primary school or from a secondary school. Trips were at weekends or in holiday time, seldom involving school time. It has now become commonplace for most children to experience one or more extended field trips away from the classroom during scheduled school time each year. The age range has been extended, mainly downwards, and now includes extended trips for 6- to 7-year olds. The number of extended trips has also increased in the secondary schools, but these usually overlap with non-instructional time. Most trips are organized for grades five, six and seven, i.e. ages 12 and 13.

The most common trips are those of five days' duration to attend a school camp. Four of the seventy-five school districts own and operate their own school camp at an established outdoor environmental centre. These are in operation from Monday to Friday throughout the school year. Transportation to and from the camp is made available and all instructional equipment is provided on site. A permanent kitchen staff prepares and serves meals. Students are charged directly for these food costs. Teachers must attend an orientation workshop prior to their use of the site by classes.

Four additional school districts rent facilities, buildings, instructional equipment and staff from private campsites and operate them as district environmental centres.

The Canadian Forestry Association operates five environmental centres across British Columbia. Individual teachers make their own arrangements for the use of these centres. Programmes are organized by the centre personnel and the users pay a rental fee for the full use of the facilities, staff, equipment and programme. Other teachers independently utilize a variety of church and other private group campsites on an ad hoc basis to provide their classes with a school camp experience. Still others, a brave and hardy few, choose their own site and, with the help of their students, make it into a campsite as part of the programme.

Suggestions for organization

Two types of planning are required for each trip:

1. Logistic planning which involves the technical details to ensure the success of any group outing.

2. Programme planning to ensure a valuable educational experience.

Many manuals, handbooks and brochures outline procedures for the organization of field trips or school camps.

The first type of planning is usually well done, but the second type of planning requires comment and suggestions. What is important is not where the site is located, but what is done at the site, what is done prior to the visit, what is done en route to and from the site and what is done as a follow-up.

There are two standard pitfalls into which most field trip programmes fall:

1. Upon arrival at a centre, students file into a classroom similar to the one that they have just left at school, to be shown or told about the programme

offered by the centre. The main motivation was the visit to the centre. Now this must be suppressed until the education officer or the instructor is ready to move on. Re-motivation may be necessary before the trip can continue.

2. One of the saddest events to witness at a local zoo – even sadder than animals enclosed in their concrete cells – is that of students with a long list of questions that must be answered. These questions require at least an encyclopaedia if not an entire library. Students spend their time at this chore trying to outguess their teacher, borrowing answers from one another, but seldom glancing at the animals. The completion of the assignment is of greater importance than the educational experience.

Examples of a positive approach for a visit to a zoo – suggestions for the teacher

1. Use the site to which you have taken your class, often at considerable effort and expense, to its best advantage. Use your time while at the site efficiently. Do only those activities that can best be done on site and leave related activities for elsewhere. The 'introduction', so often considered necessary, could frequently be entirely omitted or at least given at a different time or place. Perhaps, if it is pedagogically sound, it could be presented so that the students become active participants instead of passive recipients.

2. Visit the site ahead of the field trip. Make up your questionnaire or assignment sheet on the spot so that you will know if your questions are fair and answerable through observation or perhaps manipulation. Here are some ideas that have stimulated children elsewhere:

(a) Make sketches of animals in action. Use simple line drawings that suggest actions such as walking, sitting, eating, drinking or stretching.

(b) Seek out animals that exhibit alarm, happiness, contentment, boredom, misery or fixation.

(c) Find differences in the appearance of two or three individuals of the same species. Could these features be used as 'natural' markers in the enclosure? for the zoo? for the species? i.e. giraffe neck spots, zebra stripes, lion whisker patterns, cheetah face spots, etc.

(d) Make a collection of hair and fur. Identify source. Take the collection back to class for microscopic examination and comparison.

(e) Make a collection of abandoned feathers. Match them to species of birds. Match them to type of feather and part of body. Take them back to the classroom for microscopic comparison. Dip some feathers in crude petroleum. Dip some in solvent in an attempt to clean them.

(f) Attempt to collect footprints of birds and perhaps some other animals.

Entice them to walk through mud and then over heavy paper.

(g) Record sound of birds or other animals on tape. Play back to same individuals. Play back to other individuals of same species. Play back to other species.

3. If this is to be the first visit of your class to that site, then allow them time to explore widely and quickly without specific questions to be answered. Then ask a few general questions, e.g.: Which animals do you like? Dislike? Assign students to watch one animal for one minute (or perhaps five or ten minutes). Ask questions related to feeding, grooming, behaviour related to captivity or abnormal activity.

4. If a repeat visit is planned, then ensure that one or two aspects of the site are examined in detail. Several trips could then be made to the same area without overlap of subject materials, i.e.:

(a) What are some similarities and differences between species of cats?

(b) What are some similarities and differences between species of antelope?

(c) Compare a specific animal with a similar species found in a different part of the world.

(d) Discuss with zoo personnel their animal breeding programme, its success or lack of success.

5. Involve your students in the planning of the trip. Take two or three along on your preliminary visit as you plan each trip. Ask them to make up some questions that the other students might answer. Observe and listen to your students for ideas that might involve others.

6. Listen to the message your class is trying to send: 'Do we have to go to the zoo *again*?' or 'We went to the zoo last year.'

7. Pre-trip planning. Do not tell the class all about what is in the zoo or what they are to see and do. Leave the details for work within the zoo until you arrive. Use the motivation for the trip to reinforce or develop other skills such as map reading, compass directions, bus routes or relative size of the zoo as compared to parks or schoolgrounds.

8. Follow up the trip with some materials brought back. Use the data collected, augmented by library studies. Again, study the zoo as a unit. Some projects for discussion or further data gathering might include: Is the zoo in the best location for a zoo? Could the land be better used for something else? Are there any political issues over its location? or cost of operation? What are the thoughts of nearby neighbours as to noise? traffic? smells?

School camps

These are usually organized to meet the special needs of traditional school subjects such as mathematics, language, geography, history, art and so on. The programme normally involves three phases: the academic phase (devoted to one of the subjects mentioned above), the recreation phase and the social living phase. The academic phase will have its scheduled times of meetings, recreation periods will be designated and the social phase will occupy all other hours.

In a recent survey of the likes and dislikes of students who had participated in school camps, the strongest dislike was 'standing around waiting for something to happen'. A follow-up study endorsed this finding. There is, perhaps, some weakness in the academic-recreation-social structure which makes time wasting inevitable. Some suggestions, therefore, are offered, for a more efficient use of both time and the resources of the site:

1. Integrate the three phases mentioned above. Why should every person be doing the same thing at the same time? This makes for a sensible use of equipment and of space.

2. Use the evening period for studies. This can seldom, if ever, be done in school. Particularly suitable subjects for evening classes are, of course, astronomy or just plain star-gazing; sunset, sunrise and night sound also fit this pattern. Here, too, is an excellent period to record weather data not normally observed.

3. Most camps are inundated with negative injunctions 'Don't run', 'No swimming', 'Do not light fires', 'No cutting of trees', 'Keep off the grass', etc. Replace these (if they are truly necessary) with positive signs. 'No running' might become 'Please walk in a quiet, respectful manner'.

4. Set aside places where the forbidden activities may be carried out. 'The use of axes, knives and saws is allowed only in this area.' Set aside an area where one tree, one stump and one log may be hacked, cut or otherwise mutilated. Similarly, an area should be set aside for fire lighting, and yet another area where digging or planting may be carried out.

5. Arrange for camp staff to share their duties in shifts. In most camps, all members of staff are on duty for sixteen hours a day from Monday to Friday as long as classes are present. This should not be. Shifts of not more than eight hours are perfectly practical. Additional supervision will be necessary. Part-time volunteer supervisors are readily available among older students who may be in special community activity programmes as part of their secondary school courses; parents; people who have retired; workers on holiday; injured people who are convalescing; and, at weekends, ordinary interested citizens. The supervision ratios recommended by national youth organizations across Canada are: one to ten for adults, one to eight for older children and one to six for young children.

6. Help out the cook and, at the same time, give your programme more flexibility. Most camp programmes are organized around the cook's schedule. A compromise can be worked out so as to reduce the cook's work. Set up a buffet

lunch counter where students can come to lunch individually or in groups at oheir convenience and make their own lunches. Retain the evening meal as a family gathering. It may be necessary to trim the financial budget by using students in the kitchen, but from the educational aspect it is an inefficient use of the students' time.

7. Arrange grouping on strenuous activities so that the more robust students are the most challenged. This might involve travelling a greater distance to reach a designated destination, or travelling by a tougher route or simply staggering the times of departure so that the stronger group leaves last and must travel faster to arrive on time.

8. A better preparation of teachers for this type of activity is essential. Instructions in logistical and programme planning should be incorporated into programmes of teacher education. In-service training programmes should be provided to aid those teachers who require or desire additional help and information. The Canadian Forestry Association frequently provides weekend workshops for teachers and sometimes children are also involved. Private companies arrange week-long workshops and visits to forest operations and mining activities at no charge to the teachers. Teachers are released from class during school time for these sessions. A second forestry organization, the Festival of Forestry, arranges tours of forest operations for combined groups of forestry and education students from the local universities.

9. Evaluation is necessary to show the worth of out-of-classroom experiences. Surveys of teachers, principals, parents and student participants can be used in attempting to measure the value of these programmes.